August-September 1969

EMO

North American Air Defence
Soil in a Nuclear Emergency
The Importance of Civil Defence
A Brief on Disaster Plans
C. D. Little Harbor Report—II
U. S. Views on Civil Defence

CANADA EMERGENCY MEASURES ORGANIZATION

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In addition to publishing articles which reflect Canadian Government policy the Digest may also publish articles by private individuals on subjects of current interest to the emergency measures programme. The views of these contributors are not necessarily subscribed to by the Federal Government.

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NORTH AMERICAN AIR DEFENCE

by
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Defence Research Board
Department of National Defence

On Tuesday, May 13, 1969, Dr. Lindsey appeared as a witness before the Standing Committee on External Affairs and National Defence. The following is the text of his verbal presentation to the committee excerpted from Minutes of Proceedings and Evidence, No. 43.

Thank you, Mr. Chairman. Both subjects that we are planning to discuss in the next two sessions are terribly complicated. Either air defence or ballistic missile defence are subjects of such complexity that one could selves, but you cannot really do that very sensibly if you spend a great deal of time talking about them in them- are trying to get down to the basic purpose of the two. One has to consider them as part of an even bigger system, and an even more complicated one. Perhaps, in these days of systems analysis, we are dealing with one of the biggest and most important systems that has ever been created by men, and it is a terribly dangerous one. That is why in the written material a certain degree of space was taken to discuss the strategic background and the whole question of stability and the possibility of nuclear war.

ABOUT THE AUTHOR

Dr. George R. Lindsey was born in Toronto in June, 1920, where he received his primary education and obtained an Honours B.A. in Mathematics and Physics at the University of Toronto in 1942.

He then joined the Royal Canadian Artillery and served in Canada with the Canadian Army Operational Research Group, and overseas with the British Army Operational Research Group.

Following his retirement from the Canadian Army in 1945, he resumed his studies and obtained a Master's degree in Physics at Queen's University in 1946. He obtained the degree of Doctor of Philosophy in 1950.

Dr. Lindsey joined the staff of the Defence Research Board's Operational Research Group in 1950 and in September, 1961, became Chief of the Operational Research Group at the Anti-Submarine Warfare Research Centre of the Supreme Allied Commander, Atlantic. In September, 1964, he was appointed Deputy Chief of Operational Research and subsequently, Senior Operational Research Scientist in the Operational Research Division, Canadian Forces Headquarters. He became Chief Superintendent, Defence Operational Research Establishment in 1967, and after reorganization in 1968 was made chief of the Defense Research Analysis Establishment of the Defence Research Board.

Dr. Lindsey is a Member of the Canadian Institute of International Affairs, the American Statistical Association, the Royal Astronomical Society of Canada, the Institute for Strategic Studies, the U.S. Naval Institute, and the Operational Research Society of America. He is a past president of the Canadian Operational Research Society.

I think that the first two parts of the report have been distributed to the members of the Committee. It took a lot of work in order to have them ready by Friday last, and unfortunately, it was too late to have the translation in French. This is a pity, but indeed in order to discuss the matter we have used several new words in the odd terminology of the American nuclear strategists, and I have great sympathy for the translators.

Stable Mutual Deterrence

In the first part of the written text, the subject to which the most attention was paid was the one of stable mutual deterrence. It is believed by a great many responsible people that this does come as close to a solution of the difficult problems of the world as we are liable to find for many years.

Stable mutual deterrence is imperfect, it costs a lot of money, and it is fashionable to cast aspersions on it. But it really has served us very well, and I think it behooves us to study it pretty carefully before we consider trying to replace it by something else.

I would like to say a little bit about each word, "stable" "mutual" and "deterrence". By deterrence, we mean the ability of one country to be able to punish its adversary no matter what the adversary may do to it. If we want to talk about A and B, to prevent specific names from being mentioned, A deters B if B recognizes that no matter what B does to A, A can still reply and mete out a dreadful punishment on B. In that case we say we have deterrence.

The word "stable" is very important, and by stability we have tried to imply in our paper two different features of deterrence. First of all, to be stable it is important that the ability to mete out the retaliation should not depend on having what is sometimes called the hair trigger response. That is to say, if A wishes to be able to reply to B for something that B has done to him, it is highly desirable that A should not have to act in a big hurry; or to have to set all his degrees of response to a level where he would have to reply violently to a dangerous situation, or what looks to him like an attack, although it has not actually been confirmed.

He should be able to reply deliberately, involving all the processes of consideration that one would wish to exercise with a terribly important thing like this. He should not have to reply in a hurry, if necessary he should be prepared to let the attack fall, to ride it out, and to have available to him, hours later if necessary, (conceivably even more than that), sufficient deterrence that he could still punish the attacker for everything he had done. One of the features of stability is that you should not have to reply in a hair-trigger way.

The other feature of stability is that it should not be sensitive to the exact numbers of weapons held by the two superpowers. In other words, if the deterrence were stable today, then if one side hears that the other side has developed a few more weapons of one kind or another, it should still be stable tomorrow. This should not cause either side to panic and have to take some immense reaction. So stable implies both of those things, as used in the paper.

The third word, "mutual" is fairly explanatory in itself. It just means that whatever applies in one direction, from one superpower to the other, applies equally in the other direction. In discussing this sort of thing I think we have to be rather nonpartisan, talk about A and B, and treat the two superpowers equally. We do not want either one to start a nuclear exchange.

The Interaction of Strategic Offensive and Defensive Systems

In order to talk in a little more detail about these systems we have to discuss something of the technical features of the offensive and defensive systems that form part of the mutual deterrent.

On figure 1, we have shown the United States at the top, the Soviet Union at the bottom, we have grouped the United States offensive weapons at the upper left, the Soviet defensive weapons below them, and the Soviet cities and rural population on the lower left. Then on the right side we have the Soviet offensive weapons, the American defensive weapons, and the American cities.

We will discuss these blocks in a bit more detail. Let us start with one of the United States offensive weapons, the bombers. The main features of bomber aircraft are as follows. They are very vulnerable on the ground. Once they are in the air they are not subject to bombing by other aircraft or to attack by strategic missiles. They can carry a large payload and deliver it very accurately, but it takes them quite a few hours to fly from their home bases in North America to their targets in the Soviet Union. They may have to penetrate air defences. They are effective in bombing missile sites or bomber bases, provided the missiles and bombers are still there to be attacked when they arrive, and they are very effective in attacking cities.

The second weapon is the ballistic missile submarine. The better ones today have nuclear propulsion, and they fire submarine launched ballistic missiles-SLBMs, To carry out their task they have to penetrate an anti-submarine defence which is directed against the submarine itself, and if they fire their missiles the missiles may be intercepted by a ballistic missile defence system. When we put an anti-ballistic missile system on the diagram we are assuming that if it is able to intercept an ICBM in flight it can probably also intercept an SLBM in flight. Because the weapons carried by the submarines are somewhat less accurate and somewhat smaller than the ICBMs they are not likely to be effective in attacking ballistic missile sites if the sites have been hardened. They would be very effective in attacking bomber bases and very effective in attacking cities. The SLBMs that one hears about today are the Polaris and Poseidon of the U.S. Navy.

Then the third and perhaps the most important element in the offensive system is the intercontinental ballistic missile. It can be made comparatively invulnerable by burying it deep in a hardened silo, and both sides have done that with practically all of their ICBMs. It is very accurate, carries a large payload, may have to penetrate a ballistic missile defence, and has a certain effectiveness in attacking the opposing ICBMs, but that depends very much on technical features like accuracy, weapon yield and the hardness of targets. It would be very effective in attacking bomber bases if it could catch the bombers on

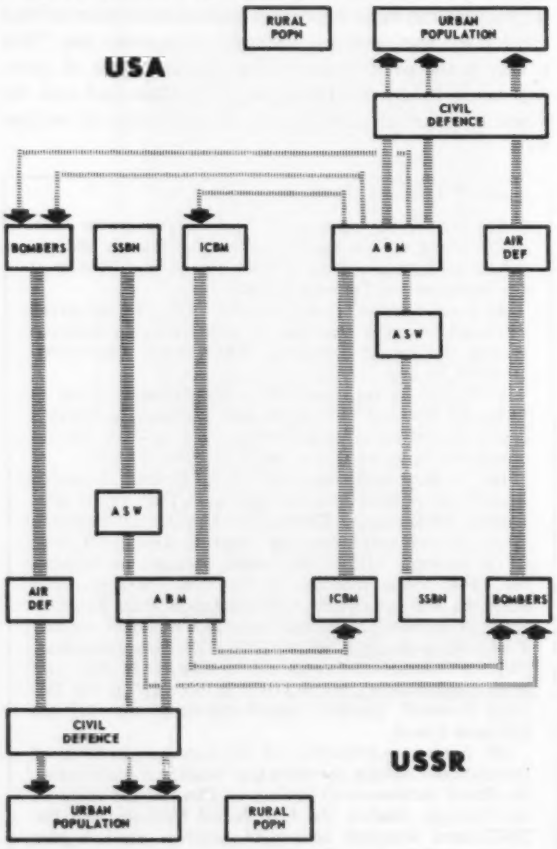


Figure 1

the ground. It would be no good for attacking submarines at sea, which are practically invulnerable once they have left port, and of course very effective in attacking cities.

As far as defensive systems go, air defence opposes the manned bomber, anti-submarine defence opposes the submarine itself, and ballistic missile defence opposes intercontinental ballistic missiles and also submarine launched ballistic missiles. Then we have civil defence, which will reduce the casualties, and perhaps save property by stopping fire spreading in the cities.

One of the advantages of civil defence is that it applies against all these weapons, and if somebody invents a new way of delivering nuclear weapons on cities it is very likely that civil defence would help to save the city against that one too. We should remember that both countries also have a very large fraction of their population outside the larger cities, and they are generally not endangered by this sort of exchange nearly as much as the people in the large cities. The only condition under which they would get in serious danger would be if there were dangerous fallout spread widely around whole areas of the country.

The bottom half of Figure 1 is really just the mirror image of the top, and we could say the whole thing again, although some of the labels on the national weapon systems would be different.

There is a certain jargon which one finds in the literature on this sort of subject today, and I think we will have to use some of those words if we are going to understand it thoroughly. Also, it helps us to comprehend the literature that comes out today. Generally, the Counter Force Strike is one which is delivered against the offensive systems. A Counter Value Strike is delivered against population, but it could also include other valuable assets of a country like a big dam or power station.

What we have tried to show you on Figure 2 is a very rough picture of the situation as it exists today, and to illustrate why we have mutual stable deterrence in 1969. The way that we illustrate it is to show what would probably happen if the Soviets should try a Counter Force First Strike, say, today. Suppose, for the purpose of the argument, that they use all their ICBMs on this Counter Force First Strike. The American anti-ballistic missile box is empty, because today the United States has no ballistic missile defence. Therefore the ICBMs could be directed against the American Minutemen and Titan ICBMs and the bomber bases. If they were caught by surprise and did not react fairly quickly, undoubtedly a number of bombers, and also a number of ICBMs would be lost. However, today, knowing the vulnerability of these, we would assume that the vast majority of the ICBMs would survive and probably quite a few of the bombers. The submarines are really not a risk against the Counter Force First Strike — at least not the ones that have put to sea. They are not vulnerable to this sort of thing. If the United States wishes to make a Retaliatory Counter Value Second Strike against the Russians they have the survivors of these systems, and there are lots of them, but they have to cope with the Russian air defence, which is quite good, the Russian anti-submarine defence, which is probably not as good as the western one, and they would have to cope with an anti-ballistic missile system which is not a very thick one. It is almost certain that each one of these three weapon systems would be able to penetrate these defences and would be able to wreak on the urban population, in spite of the best that the Russian civil defence could do, a dreadful punishment. That is why we say that there is deterrence. It is stable because these systems are sufficiently invulnerable that they do not have to start the second strike the minute they think the first strike might be coming; they can sit and take it, and still deliver a completely adequate reply. Therefore it is stable from that point of view. It is also stable from the other point of view. If there are perhaps 1,000 of these ICBMs today, but if it went up to 1,100 tomorrow, or if the number of SLBMs and the number of bombers went up a little bit, the condition would still apply, and we would still have the mutual stable deterrent tomorrow.

In Figure 2 I did not show the submarine launched missiles and the bombers taking part in the Counter Force First Strike. But they could do that. They very well might, but if they did, it is not believed today that even that

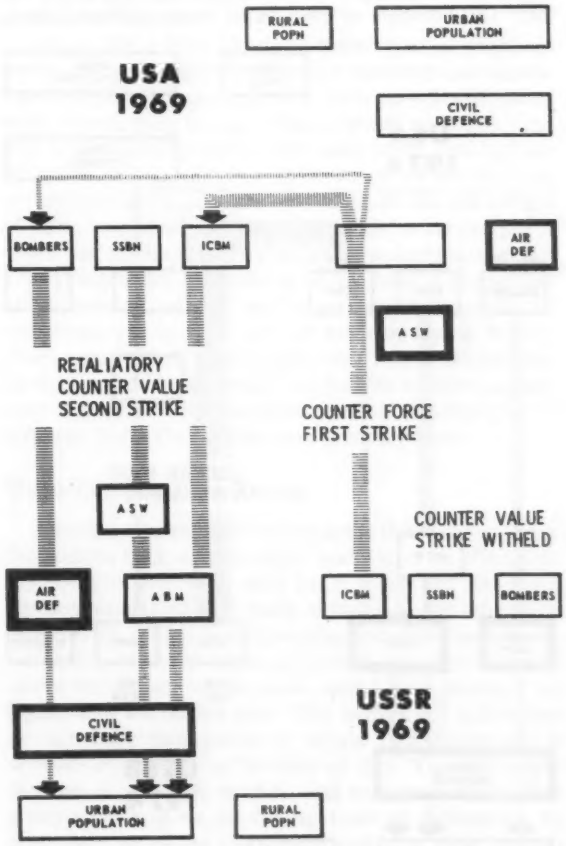


Figure 2

would enable them to be successful. The other thing that they might do with some or all of these weapons is to save them as a threat against the cities. Presumably what the first strike man would like to do would be to disarm his opponent and then tell him in the subsequent confrontation, "I still have enough weapons to murder you — you had better give in." They could save any of these for that rather unpleasant purpose. Today, if all of them were in the first strike, they still would not get away with it.

A lot of the plans and discussions that we have heard about recently in the United States on strengthening of defenses are being considered because there is a real fear in some quarters that this desirable state of mutual stable deterrence might not last very many more years.

So what we have indicated on Figure 3 is a possible development that might lead to the loss of the mutual stable deterrence. For example, if by 1974 the Soviets increase their offensive force by having 500 of these big SS-9 very large payload rockets with multiple independent re-entry vehicles, they would then have 1,500 of those warheads. They would also have their other 800-odd ICBMs. Perhaps, their submarine fleet will build up to have 1,000 deliverable warheads, probably from SLBMs with multiple warheads. Finally, they may keep their 150 bombers or even build some additional ones.

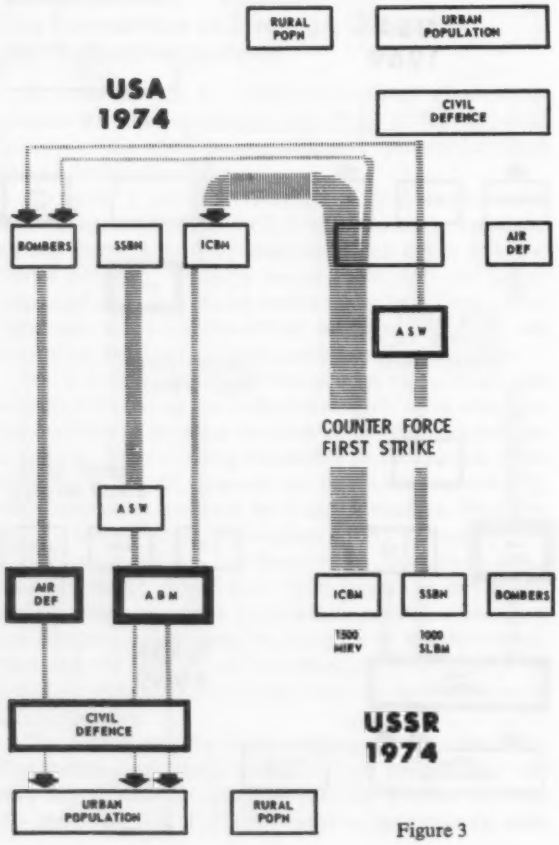


Figure 3

In order to upset this balance, they would also have to do something on the defensive side. Let us suppose that they strengthen their air defence, and build a thick anti-ballistic-missile system. Now what could happen? Supposing they deliver their Counter Force First Strike which is based primarily on the missile attack, and that the United States has done little or nothing to change what it has today. The ICBMs would not have a ballistic-missile defense with which to cope. The submarines would still have to face anti-submarine defence, which is not as effective against the first strike as the second. The SLBMs would have nothing to oppose them, so they could deliver a very heavy attack on the Minutemen and bomber fields. The submarines would still be invulnerable, except the ones which were left in port. Now the U.S. have a greatly weakened ability to reply in the second strike. The number of surviving ICBMs might be only a small fraction of the ones before the attack. A certain number of bombers would probably escape, but perhaps not very many. However, all of the SLBMs would still be available. This very reduced number of bombers would have to cope with a strengthened air and civil defence. The submarines would have to cope with an anti-submarine defence of an unknown strength, and a strong ballistic-missile defence. The very greatly reduced number of ICBMs would be faced by a ballistic-missile defence. By the time that the strength of the attack had been filtered down to this comparatively weak degree, and the civil defence had had some effect as well, perhaps the resulting punishment which could be inflicted on the Russian cities would be too little to deter them from initially carrying out the operation. That is what people are afraid of. Of course, if this situation arose, we would have lost our mutual stable deterrence. The bombers might be used in this sort of attack. If the air defence had lost both its eyes and teeth, this would be a very important addition to the threat. For example, if there were no air defence warning, all the bombers could be added to the short warning counterforce attack. If there were no teeth in the system then they could use more bombers and they could carry a heavier pay load. Alternately, the bombers might be used as the threat to hold the cities to ransom after the disarming process had occurred.

That is, perhaps, enough about the details of the offensive and the defensive systems. What I have tried to do is to underline the importance of the mutual stable deterrence and to explain the importance of those three words.

Possible Future Development in North American Air Defence

I think that we might discuss the second part of the paper. Indeed, this means that we are now moving into the area of study which is mainly on the agenda for today, that is to say, anti bomber defence.

What we have attempted in this part of the study is to make special reference to the future developments

in anti bomber defence which might be of interest to Canada.

Next, let us make a brief review of anti bomber defence in North America starting in its early years, around 1950 building up to 1962 where it had stabilized into a form which is not too different from the present time. The outlines in those early twelve years are that the deterrent was horribly vulnerable. It consisted, at first, of bombers on the ground, which were not able to get off on very short notice. Toward the end of the period, a few soft ballistic missiles were produced which were also very vulnerable, and which could not be used in a hurry. Quite rightly, there was a genuine fear of surprise attack. One of the things which was done in the face of this hazard was to build up early warning. The DEW Line was built along the northern coast of Canada. It was actually designed and financed by the United States but a good deal of its length was in Canadian territory. It also extended into Alaska, and Greenland. The Mid-Canada Line was built along the fifty-fifth parallel. This was entirely in Canada and was designed and built by Canadians and paid for by the Canadian government. Then the Pinetree System was built, which is the outer layer of the solid ground based control cover used to direct fighter aircraft in interceptions, as well as to control air traffic. There were several layers, but the Pinetree was the outer layer, and was in Canada. It was jointly financed and manned, but Canadian servicemen did provide the greater proportion of the manning of the system. Then there were Interceptor Aircraft which included the CF-100 which was designed and built in Canada. It was later replaced by the Voodoo. There were Bomarc Surface-to-air missiles, in both countries. In the United States, there were two other surface-to-air missiles, Nike-Hercules and Hawk, but Canada elected not to procure or deploy those weapons.

That is a quick summary of the early build-up of the air defence system. It would be possible if we wished, to continue with this type of system for a quite a long time. However, certain elements would require replacements. It seems a good idea — when we are deciding whether or not to continue it — to also decide if improvement is required, instead of simply replacing items by things of the same kind.

Let us now discuss some of the problems which will face us in the future years. We should remember when we are talking about air defence, and perhaps when some of us are making rude remarks about it — that 100 unopposed bombers could destroy North America. It is also most unlikely that 100 unopposed bombers would come by themselves. However, they are a very lethal weapon and should not be underestimated. They have equipped themselves, in recent years, with an air-to-surface missile which enables them to deliver a weapon onto a target without coming closer than a few hundred miles from it. This makes them a much more difficult weapon with which to deal. The air-to-surface missiles will probably be too small and fly too fast to be easily intercepted. Another thing that has come about since the ICBMs were installed in great numbers is that the important installations for air defense, such as the airfields, the radar stations and the control centres are now very vulnerable to attack by missiles as well as by bombers, so that the vulnerability is much worse than it used to be. An option which is available to us would be to continue the present type of system. This would give us a good defense against 100 or 150 high-altitude aircraft, with bombs that simply fall freely through the action of gravity. However, it is now unlikely that an attack would be delivered from high altitude, because the bombers have learned to fly quite low, which makes them much harder to detect. It is unlikely that they would use free-falling bombs, now that they have these air-to-surface missiles. If we continue the present type of system, it would be weak against the low-altitude penetration and the air-to-surface missile. In short, if we are going to continue air defence, we should try to make it more widely dispersed to reduce its vulnerability, and should try to extend its cover downwards so that it can catch the low flyer. It should also be extended outwards so that it can catch the bomber, even if he does not have to penetrate right into the target. These are the improvements which we would like to bring about, if we intend to stay in the air defence business.

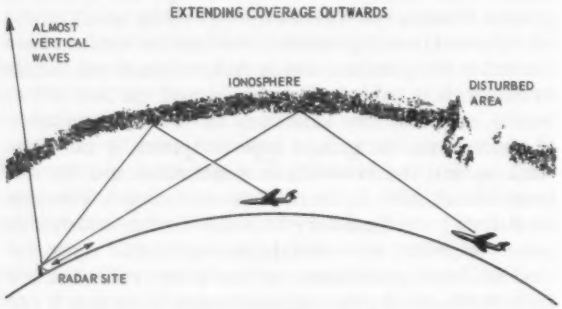
Let us talk a little bit about these types of improvements. We would like to extend it outwards and downwards to make it less vulnerable. Now we will talk about ways of extending the air defence system outwards. One way to do that is to improve the radar cover, and in these questions of long distance radar cover we will find we are always dealing with the curved earth. We are talking of quite long distances now, hundreds or thousands of miles, and on this scale the fact that the earth is curved is a very important fact indeed. If we have a transmitter and a receiver roughly on the surface of the earth, its radiations will have to go out horizontally or higher. They cannot bend around and come below the horizon. So that, normally one would not be able to detect an aircraft if it were below the horizon, and if it is flying low it will stay below the horizon until it is very close.

Over-the-Horizon Radar

A system that attempts to overcome this is called "over the horizon back scatter radar" and it uses an effect that is known to everybody who has a shortwave radio and has communicated with radio stations on the other side of the earth. This is done by making use of the ionosphere, which is a series of layers of ionized gas some distance above the surface of the earth, and I have shown it on Figure 4 by the dotted zone. This ionized gas will reflect or turn back radiowaves of certain frequencies and it depends somewhat on the time of day. You will know that too, if you have worked with shortwave radio. It is possible, then, if we use the right sort of radiowaves, to send them up to the ionosphere and have them bounce back again to the surface of the earth. If we send them

almost vertically they will go right through, but if we send them on this angle they will bounce down here, or about at the horizon they will come back to earth at a great distance away, many hundreds of miles.

It is possible to make a radar work on that principle and that implies, if a bomber is approaching, that anywhere between here and here, which would represent many many hundreds of miles — and it does not matter whether it is low down or at high altitude — it can be



OVER-THE-HORIZON BACK SCATTER FOR DETECTING AIRCRAFT

Figure 4

detected by the radar because it is bouncing signals off the ionosphere.

Here on Figure 4 I have shown the ionosphere disturbed, because in the polar regions, including a good deal of northern Canada, we have the northern lights or aurora borealis, and that represents a disturbance of the ionosphere. When the ionosphere is disturbed it is as if the mirror that we were using to reflect our signals here had been broken. If the disturbance has occurred in this zone then the OTH radar would not work. So there are some doubts about the effectiveness of the device in Canada although it would probably be quite good in other parts of the world where they do not have these disturbances.

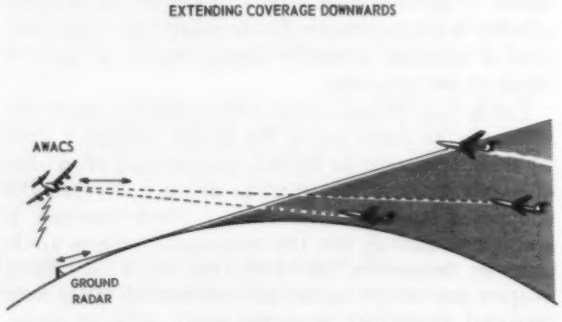
We were talking about extending our radar cover and our air defence outwards. Obviously, one very good way to do it is by using OTH for detecting aircraft at long range.

Another way of extending it outwards, which we will talk about in a minute, is to put some of the control and warning radar into aircraft, the AWACS (Airborne Warning and Control System) but there are other ways of extending cover outwards and that is to use interceptors on bases that are farther forward. So, we have several ways of extending the cover outwards, the OTH back scatter radar being only one of them.

The Airborne Warning and Control System (AWACS)

On the next slide, Figure 5, we talk about ways of extending the cover downwards, which was another of the important improvements that was needed. Here we have the curved earth and here we have a radar on the ground which can only see above the horizon in this blue zone. If an aircraft were approaching at high altitude, it would be picked up at a considerable range, say, 200 or 300 miles from the station. However, if it were approaching at low altitude, say 500 feet above the earth, it would come right in very close to the station, perhaps 25 or 50 miles away, before it came above the horizon and could not be detected until that had happened. So that, a radar on the ground, unless it uses the OTH principle, is bound to give rather poor warning of a low-flying approaching aircraft. A rather extraordinary thing is that if the radar is moved just a few miles up in the air, say six or eight miles, that it drives the horizon away a distance of some hundreds of miles. Of course, you know very well that if you climb a high mountain or go up in an aircraft you can see a tremendous area underneath you, far far more than you ever could from ground level. This is simply a manifestation of the same principle. The thing that I always find surprising is that by just going up six miles you can see hundreds and hundreds of miles farther.

If we have this radar in an aircraft, then, just a few miles up, he can see into this shaded zone on Figure 5, which is very much greater than the other one. A high-altitude aircraft might be picked up 500 miles away an a low-altitude aircraft would be picked up still, say, 200 or 300 miles away. This seems pretty easy: why did we not think of it years ago? We did think of it years ago, but there is a catch to the method of solution and that is that when the radar is looking down at the ground, naturally enough it receives a tremendous amount of energy reflected back from the ground. After all, a radar works by detecting a tiny quantity of energy that is bounced back from the surface of the aircraft target. Obviously mountains and other objects on the surface of the earth are going to return far more energy than that, and normally return so much more that they create ground clutter which completely obscures the aircraft, so that it is practically impossible to see the aircraft because of the ground clutter.



COVERAGE OF GROUND-BASED AND AIRBORNE RADARS

Figure 5

The improvement in electronic technology that has made this thing possible is a method of distinguishing the moving target of the low altitude aircraft against the

much greater clutter from the ground, and if this technique turns out to be completely successful, then in the AWACS aircraft we would expect to be able to pick up all these low flying aircraft and to have solved the problem of the low altitude tracking and detection.
However, if we are going to do that, it will take a big airplane with long endurance and it will have to fly at high altitudes. Since it is a big airplane with all those features, we might as well ask it to do the other things which we do in a radar station as well as simply detect distant aircraft. So that is why it is called an AWACS—an airborne warning and control system. The control implies that we would put into the aircraft the personnel, the displays, the computers and the data handling that would enable it to control the air defence system as well as simply performing the detection. It would be able to carry out identification, to match aircraft echoes with flight plans, and to control interceptors if necessary.

Improved Interceptors

That, then, is part of the scheme to extend the coverage downward and it involves the airborne warning and control system. But if we are going to be able to intercept low flying bombers, the AWACS will not do the whole job by itself. There has to be an interceptor that can operate against the low-flying bomber, and that means that the radar in the interceptor aircraft has got to work in spite of ground clutter. If there is an air-to-air missile controlled by radar, it has got to work in spite of the ground clutter as well. Fortunately the electronic techniques, that look as if they are going to solve the problem for the warning radar, can also be applied to the airborne intercept radar in the interceptor, and to whatever sort of guidance of a radar type there is in the air-to-air missile. So the coverage extending downward is largely to be solved by the successful application of this radar technique that enables a low-flying airplane to be detected against the ground.

Reduction of Vulnerability

I said there were three weaknesses to the present system and they were that the coverage should be extended farther out and lower down, but also that we were very vulnerable. I have not said very much about vulnerability here, but obviously if the radar is in an AWACS airplane it is not going to be at risk to a missile. So that one way of reducing vulnerability is to put our radars into the air.

Another way of reducing the vulnerability would be to disperse the units more completely. The fighter bases are vulnerable but if we were to increase the number of fighter bases and distribute the aircraft more widely we would have reduced our vulnerability. If we did that by simply setting up more permanent bases it would be a very expensive undertaking. A much more cost-effective solution seems to be to have a small fleet of maintenance aircraft that would carry the men, the instruments, the spare parts, the reload missiles, and everything else needed to keep a fighter squadron going, and fly them to these dispersed bases. That is another means of reducing the vulnerability.

I think the OTH radar will be vulnerable and not very much can be done about it.

U.S. Objectives for Air Defence

Those, then, are three ways in which it is hoped to reduce the weaknesses of the air defence system.

We should say something, I think, about the overall objectives of continuing this improved air defence system and this is a problem that has been thought about very carefully in the United States over the last few years. On Figure 6 we have summarized the exact statement of the U.S. Secretary of Defence when he was explaining what he hoped to achieve by improving and continuing the air defence system. This was a statement made by Mr. Clifford early in 1969. The first objective was peacetime identification. They want to be able to keep track of aircraft flying over North America and identify those that have come in without permission. They would like to be able to limit damage to our—and that means American—cities from a Soviet manned bomber attack, but they are quite modest in their claims in this regard and they state elsewhere that they realize they cannot do that to a very great extent without having a comparable defence against missile attack. They would like to be able to prevent damage from air attack by other countries, and in the case of the United States they have Cuba very much in mind.

They would like to preclude a manned bomber attack on the withheld strategic missile forces, and this bears on the point I mentioned earlier. They do not want to have to save their missiles by firing them at the first sign of trouble. They would like to be absolutely certain that they really want to fire them, and this means being able to take their time and be deliberate and not be panicked by the approach of manned bombers.

They wish to discourage the Soviet Union from developing and introducing new bomber threats which could be costly to neutralize. They feel that if they show that they are going to continue to oppose the present type of

U.S. OBJECTIVES FOR AIR DEFENCE (1969)

1. PEACETIME IDENTIFICATION
2. LIMITING DAMAGE TO OUR CITIES FROM A SOVIET MANNED BOMBER ATTACK
3. PREVENTING DAMAGE FROM AN AIR ATTACK BY OTHER COUNTRIES, E.G. CUBA
4. PRECLUDING A MANNED BOMBER ATTACK ON OUR WITHHELD STRATEGIC MISSILE FORCES
5. DISCOURAGING THE SOVIET UNION FROM DEVELOPING AND INTRODUCING NEW BOMBER THREATS WHICH COULD BE COSTLY TO NEUTRALIZE
6. PROVIDING A COMPLETE MOBILE "AIR DEFENCE PACKAGE"

Figure 6

(*continued on page 23*) **NORTH AMERICAN AIR**

SOIL IN A NUCLEAR EMERGENCY

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Canadians are developing one of the world's most intensive and extensive soil mapping systems, covering about 389,000,000 acres to date. This system is being developed, complete with computer data processing, through co-operation among the Canada Department of Agriculture, the Agricultural Rehabilitation and Development Act (ARDA), provincial departments of agriculture and several universities. In addition to being a valuable data source and planning tool, this computerized mapping system will be invaluable in the event of a nuclear emergency.

Canada has a diverse agricultural production pattern, varying from the prairie provinces, where wheat is king, to the Niagara fruit belt of Ontario where peaches and grapes are the most important crops. In a nuclear emergency, Canadian agricultural authorities must know the capabilities for production in areas where nuclear blasts and fallout have not seriously hampered the ability to produce sufficient and wholesome food for the surviving population. The computerized mapping system helps to make this possible.

Part of the data that is being stored and catalogued outlines the limitations for agricultural production in each farming area of Canada. The type of soil in each area is defined and identified. Planners can use this information to tell at a glance if, for example, 500 acres near Edmonton, Alberta, will be seriously affected by fallout, what crops it could produce and which crops can't be grown in the area. The Canada Department of Agriculture knows, for example, that acid soils would likely produce plants that would take up a higher level of Strontium 90. The relative merits of adding lime or fertilizer to these soils to neutralize acidity — or of looking to an entirely different region of Canada for production of these crops — can be assessed quickly and accurately.

Scientists in the Canada Department of Agriculture have learned that dietary contamination is unlikely to be the cause of concern immediately after a nuclear conflagration and that most radionuclides are unimportant when considering the soil alone because of short half-lives or low specific activity. After the immediate post-attack period, the surviving population will be concerned with the longer-lived isotopes such as Strontium 90 and Cesium 137, and efforts must be made to keep these contaminants at a minimum level of pollution. Plants will likely take up Strontium 90 more readily than Cesium 137 because the soil ties up (fixes) Cesium 137.

Plants take in radionuclides by three methods—from the air into leaves, from the soil into roots and plant-base absorption, which involves uptake through surface roots of material which has not been mixed to any appreciable extent with soil ions. This third method of uptake is of importance primarily to old pastures which have developed a surface mat and is probably much more important in England where the concept was developed than in the North American type of agriculture. Immediately after a nuclear attack, the most important mode of entry of fission products, primarily Iodine 131 and Strontium 89, will be direct contamination. Milk will be Canada's greatest concern because infants could receive a harmful dose of radiation to the thyroid. Because these isotopes are short-lived, milk can be stored or processed into butter or cheese and held until it is safe to eat. In the meantime, infants can rely on uncontaminated stored milk.

In the longer term, Strontium 90 and Cesium 137 will become more important. Strontium 90 tends to be immobile in the plant once it is deposited, but Cesium 137 will move from the site of absorption to remote organs of the plant. Soluble deposits may be absorbed through leaves, green stems or fruit, but this usually occurs slowly so that even when plants are contaminated with freely soluble materials, the major part of the radioactivity associated with them remains superficial for a considerable time. Little of this Strontium 90 taken in through the foliage will reach those parts of the shoot which are protected by outer leaves or underground organs. Floral contamination will only affect fruit and seeds. In 1963, when fallout was relatively high—though still within safe tolerance limits, scientists learned that most of the Strontium 90 in alfalfa and timothy came from foliar contamination and that most of the Strontium 90 contamination of wheat came through the flowers.

Short-lived isotopes are less of a problem in root uptake because of the length of time a crop requires to take the isotopes from the soil during a growing season. Short-lived isotopes decay to low levels during this period. Therefore, Strontium 90 and Cesium 137 are the most important problems in the case of root uptake. Strontium 90 uptake depends on both the type of soil and the plant species. A study of oats showed that the exchangeable calcium content of the soil is the most important factor, followed by other factors such as soil pH (acidity or alkalinity) and texture. Fundamentally, Strontium 90 uptake is proportional to the soluble cal-

cium present in the soil. Soluble calcium is in equilibrium with the exchangeable calcium. The scientists also learned that plants which have a high calcium content tend to have high Strontium 90 contents, and vice versa. There is a discrimination against Strontium by the grain of cereal crops which takes up lower quantities than the foliage of both Strontium 90 and calcium from a uniformly contaminated soil. In addition, seeds such as alfalfa in a forage crop take up more Strontium 90 and calcium than grasses do. Outer leaves and vegetative organs of vegetable crops take up considerably more Strontium 90 and calcium than do the seeds, fruits or inner leaves. Potato tubers take up considerably less Strontium 90 and calcium than do their tops.

The uptake of Cesium 137 by plants from soil makes a negligible contribution to the contamination of annual crops—provided the soil is of the mineral type. Although the soil factors which contribute to the uptake of Cesium 137 by plants are more complex than those for Strontium 90, and although it is doubtful that sufficient research has been carried out so far to know precisely what all the important soil factors are, scientists do know that potash (potassium) content of soil influences Cesium 137 uptake. There is also good reason to believe that plants will take up more Cesium 137 from acid than alkali soils. This is because less Cesium 137 is fixed (tied up) by acid soils. The computer mapping system pinpoints the soils that have higher acidity, so in the event of a nuclear emergency, agricultural experts will know what degree of pollution to expect in plants grown on soils with different pH readings.

There is a special situation in the far north pertaining to Cesium 137 levels found in Eskimos feeding primarily or to a large extent on caribou meat. It has been found that the Cesium 137 content of lichens and similar plants in the far north is very high. This is attributed both to direct absorption and to the accumulation of Cesium 137 by the slow growing above-ground parts of the plant from root absorption. Reindeer and particularly caribou feed on the growing tips and consequently have an abnormal concentration of Cesium 137 in their meat which is consumed by Eskimos. Eskimos were found to have body burdens of Cesium 137 up to 30 times as high as a control group. There's a compound problem involved because one of five lichen species caribou eat concentrates more Cesium 137 than the other four. It's also the caribou's favorite lichen.

In the United States, scientists have tried decontaminating soil by three methods—harvesting the crop, using a street vacuum sweeper to suck up the fallout contamination from a clipped meadow and scraping away the top layer of soil with a road grader, bulldozers and various types of scrapers. All of these methods are expensive and the first two won't completely remove the pollution. Another approach is to apply fertilizers and amendments to the soil. In general, the concentration of radioactivity in crops is lower when yield is high. Many factors may contribute to this—an increased rate of growth may dilute the absorbed radioactivity to a greater extent with the products of photosynthesis; a greater root habit may cause the roots to explore less contaminated soil. Rapid growth is likely to reduce the effects of direct contamination as the material which lodges in plants will be associated with a greater mass of tissue. More specifically, because scientists know that plants growing on acid soils take up more Strontium 90, they know that adding calcium salts to these soils will reduce Strontium 90 uptake. Besides, this is normal good farming practice. In one test in 1962, the Strontium 90 level in one variety of oats dropped to a fifth when lime was added to the soil. Although liming benefits acid soils, it is of little use on neutral soils. For some of these soils, notably those of low calcium status, the application of moderately high levels of potassium fertilizers will decrease Strontium 90 uptake by crops. Cesium 137 is reduced in concentration in crops by the application of potash in much the same way as calcium reduces Strontium 90 content.

Both Strontium 90 and Cesium 137 uptake are affected by cultivation. If farmers put these radioactive isotopes deep into the soil with fertilizer, the uptake by wheat and timothy is reduced markedly. With alfalfa, the Strontium 90 uptake is aggravated by a combination of shallow fertilization and placement of Strontium 90. A combination of deep placement of Strontium 90 and shallow placement of fertilizers reduces the Strontium 90 uptake to the greatest extent. A generally similar result is obtained with Cesium 137.

An alternate approach is to grow crops other than food on the most heavily contaminated land. This could include cotton or, in Canada's case, seed production. There is experimental evidence that seeds produced on contaminated soils won't produce crops with pollution problems. Most of the radioactivity remains in the seed, cotyledon or hypocotyl in the germinating plant; Strontium 90 does not move upward to the new seed in the second generation.

Other scientists are working on the removal of contamination from food. In nature, there are some nearly perfect packages that can be removed to leave the nutrient relatively uncontaminated—packages such as the sheaf over an ear of corn, a fruit or tuber with an impervious skin, an egg shell or perhaps a pod that protects the inner seeds. Only leafy vegetables will be directly contaminated and will require careful washing. Contaminated animals, if they are brushed or vacuumed before slaughter and the hides carefully removed, present high protein food. If it shows signs of radioactivity it can be canned or processed further and the isotopes will decay with storage.

With processed foods in storage, there is the added protection of can, packages or wrap. Under conditions of significant contamination, removing dirt and debris will effectively remove most of the radioactive contam-

(continued on page 23) **SOIL**

THE IMPORTANCE OF CIVIL DEFENCE

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Civil emergency planning, organizing the defence of the home front and mobilising national resources for an emergency, is a subject of vital importance. Although such planning is essentially a national responsibility, NATO is constantly at work in order to advise member countries and ensure the maxi-co-ordination of their efforts. The following article describes how the NATO headquarters goes about this task.

Article 3 of the North Atlantic Treaty lays down that: "In order effectively to achieve the objectives of the Treaty, the Parties, separately and jointly, by means of continuous and effective self help and mutual aid, will maintain and develop their individual and collective capacity to resist armed attack."

Consequently, the members of the Alliance are obliged to maintain and develop their civil potential in peacetime, and to prepare for the particular situations arising in time of war.

Civil Emergency Planning, as far as NATO is concerned, covers the measures which are necessary to enable each NATO country to resist any kind of attack, including a thermo-nuclear attack.

In any future war there will be two fronts to defend: the Military Front and the Home Front. They are complementary and of equal importance, as between them they form the NATO shield.

The responsibility for home defence is essentially national. But the measures adopted by individual governments are reviewed each year by the Council, which can thus note progress and assess the general state of preparedness throughout the Alliance.

Emergency Plans

The general co-ordination of civil emergency planning is undertaken in NATO by the Senior Civil Emergency Planning Committee, set up at the end of 1955. Its members are officials responsible for civil emergency planning in their own countries, who meet twice a year under the chairmanship of the Secretary General or the Assistant Secretary General for Defence Planning and Policy. In the intervals, the Senior Committee meets normally once a month, under the chairmanship of the Director of Civil Emergency Planning, at the level of representatives from the national delegations to NATO, to prepare studies on such questions as: wartime organization of transport, supplies, and refugees. It also co-ordinates the work of a number of specialised Boards and Committees, such as the Civil Defence Committee, the Food and Agriculture Planning Committee, the Industrial Planning Committee, the Petroleum Planning Committee, the Planning Board for Ocean Shipping, The Planning Board of European Inland Surface Transport, the Civil Communications Planning Committee and the Civil Aviation Planning Committee. These bodies receive guidance from the Senior Committee on specific subjects of international planning to be studied. Each year they report planning progress to the Senior Committee.

On the International Staff there is a Directorate of Civil Emergency Planning which includes staff officers for Civil Defence, Transport, and Resources Management. Certain Officers concerned with exercises and communications in the Executive Secretariat work also for the Directorate in their respective fields.

In order to guide the work of Civil Emergency Planning, the Senior Committee has laid down certain planning assumptions derived from advice provided by the Military Committee. Each of the Committees has accordingly been given an appreciation of the types of attack which could be delivered by an enemy, the most important and most likely targets, and the general effects which modern weapons may be expected to have. The Senior Committee and its Boards and Committees have given special attention to guidance regarding a general nuclear attack, since this is the most devasting type of warfare which could be launched against NATO. Another important problem is that of a warning system. It is probable, although of course by no means certain, that there would be a warning period during which certain emergency measures could be executed. This period is particularly significant in that such measures as the evacuation of the population from probable target areas have to be pre-arranged.

One task on which a NATO working group is engaged at present is to arrange an "international fallout warning" for which bilateral agreements are being worked out. Such a warning system necessitates close international co-operation in, for example, the exchange of meteorological information, particularly in regard to upper winds at heights of 80,000 to 100,000 feet.

Survival Requirements

In the case of the explosion of a 1-megaton H. Bomb, virtually complete destruction would occur within a radius of 1.8 miles from the point of explosion (ground zero point) and severe destruction to a distance of about 4 miles from ground zero, while moderate damage and partial damage would occur respectively up to a radii of 5.5 to 7.4 miles from the point of explosion.

The explosion of a 50-megaton bomb (equivalent to 50 million tons of TNT) would result in total destruction within a radius of 9 miles from the point of explosion, irreparable damage to approximately 27 miles, and severe devastation with some chance of survival in the areas between 27 miles and 45 miles from explosion point. Beyond that there would be a zone of partial damage within 57 miles. The effects of radioactivity would, however, extend to approximately 100 miles, since gam-

ma rays can prove fatal even at this distance. There can be no doubt that any attack with thermo-nuclear weapons would be particularly devastating Apart from vast numbers of people killed outright and many more injured, transport and communications systems would be destroyed or crippled and production, public utility systems, etc., destroyed or severely damaged. The magnitude of the resulting problems of these destructions point to the need for carrying out preparations for this critical period as far forward as possible in peacetime. The aim of civil emergency planning is to reduce the effects of enemy attacks on the civilian population, its main object being the saving of human lives and the limitation of damage.

Maintenance of Government Control

The first step after the attack is the "survival period" during which it is of vital importance that control should be maintained at all levels of government, both central and local, during the survival period. If this is to be done, there must be adequate emergency legislation. Almost all member nations of the Alliance have pronounced themselves satisfied in this respect with the legislation they have enacted. It is also essential that arrangements be made providing for protected wartime headquarters away from main target areas for both central and local governments. It would certainly be impossible for the actual business of government to continue to be carried out according to peacetime methods and procedures. Drastic steps, requiring the advance assignment of tasks and responsibilities, would undoubtedly be necessary. A special study of the requirements of emergency planning in this field has been made by a NATO working group.

Survival of the Population

The supremely important problem of the survival of the population can be tackled either by removing people from probable target areas or by providing them with shelters, or by combining the two measures. The cost of building shelters to give adequate protection against all the effects of a thermo-nuclear explosion within a radius of about 5 miles is enormous, and most members of the Alliance have not so far attempted to make such provision. On the other hand, general agreement has been reached that provision should in any case be made for shelter against fallout. Most countries are studying measures which can be applied to different types of dwellings, commercial buildings, etc. and a special NATO working party is responsible for making technical recommendations to the Civil Defence Committee on all aspects of this problem. It is generally accepted that a balanced combination of evacuation, or dispersal, and shelters provides the broad answer to the survival problem. The general policy then is to aim at evacuating or dispersing people from the centre of probable target areas and providing shelters for the remainder. Evacuation and dispersal plans are being worked out by most NATO countries and, in some, a number of practical tests have already been carried out. With regard to shelters the process is much slower because of the cost, but plans are being carefully studied, with particular emphasis on fallout.

A well-organized civil defence is an essential part of survival. A number of NATO member countries have established civil defence colleges to train volunteers who would form the cadres for civil defence teams. Their training includes theoretical courses given by lecturers and practical field-work arranged by instructors. In most European NATO countries civil defence is divided into two echelons, the first consisting of volunteers responsible for local defence, and the second comprising mobile columns. In North America there are also local volunteers, but mobile columns are replaced by volunteer mutual support arrangements organized in areas surrounding probable targets.

Usual Elements

A civil defence organization normally contains the following elements:

- A Control Section, responsible for the direction of operations and for certain important reconnaissance duties, particularly in connection with radio-active fallout.
- A Warden Service, which forms the main link with the civil population and has important duties on the ground, such as reporting damage and casualties and carrying out reconnaissance for radio-activity. This section must work closely with the police and in some cases is actually run by them.
- Rescue and First Aid. Personnel in this section are trained particularly to deal with casualties trapped under debris.
- The Ambulance Section is normally equipped with stretcher bearers trained in first aid. It may also include mobile first aid posts.
- The Welfare Section, generally staffed by women, covers all the welfare needs of people bombed out of their houses or evacuated, and deals with emergency feeding, clothing, etc.
- Communications. The importance of adequate communications is so great that there may have to be a special communications section which would deal with wireless messages, messengers, etc.
- The Fire Service may be separate, as in the United Kingdom, or it may be an integral part of civil defence. This peacetime service needs to be greatly expanded in time of war. One of its biggest problems is the provision of water for firefighting since it is almost certain that water mains will be broken and supplies disrupted and it will be necessary to rely entirely on static water supplies from rivers, lakes, or artificial dams. Arrangements for the provision of static water must be carefully worked out in peacetime

and may involve considerable expenditure.

- The Police is a peacetime service which must continue during the time of war with the task of maintaining control. Again, normal peacetime forces will need to be augmented by volunteers.
- Self-help. However efficient the Civil Defence and other services may be, they will probably never be sufficient to meet the enormous problems which would arise in wartime. Particular importance is therefore atached to self-help on the part of the civil population. This means, first of all, educating the population in what it may have to face and how it can help itself. Self-help means acquiring some elementary knowledge about first-aid, home nursing, fire-fighting and emergency cooking and knowing what sort of reserves of food and water to have in the house. In any future war the entire nation would be in the front line and every responsible person must therefore be trained to defend himself and his home and so make his contribution to maintaining the integrity of the home front.

The NATO Technical Boards and Committees

Civil Defence is dealt with in NATO by means of a Civil Defence Committee which has set up working groups to consider problems of special technical difficulty or importance. There also exists as part of the Civil Emergency Planning Directorate a Civil Defence Staff Officer whose task is to advise all NATO committees and NATO countries and to act as a clearing-house for the exchange of information.

In order to survive, the population must be fed. The Food and Agriculture Committee is concerned with seeing that all NATO countries have sufficient stocks of food. It has recommended that all governments should initiate an official policy of encouraging the population to build up household stocks as a vital measure of survival. Obviously, under fallout conditions, countless lives would be saved by such measures. In order to give guidance to countries, the Committee has prepared a detailed report on the protection of food-crops and livestock from radiation.

During the recovery period after a nuclear attack, surviving industry will have to be put back into operation as soon as possible to ensure the countries' vital needs. Vital installations that have been damaged will have to be repaired, existing raw materials will have to be allocated by priorities. All this entails advance planning on a national basis. The Industrial Planning Committee studies these problems and furnishes guidance to the countries of the Alliance.

Arrangements to ensure adequate fuel supplies for civil and military use in wartime are the responsibility of the Petroleum Planning Committee so far as petrol, oil and lubricants are concerned. Solid fuels have already been dealt with by another committee, which is now inactive.

The maintenance of all forms of transport is of vital importance. The problems of shipping are dealt with by the Planning Board for Ocean Shipping; of inland transport and emergency port facilities by the Planning Board for European Inland Surface Transport; and of air by the Civil Aviation Planning Committee.

If control is to be maintained, good comunications are essential. In the event of thermo-nuclear war it is to be expected that telephone and telegraph systems would be badly disrupted. It is necessary, therefore, to ensure that wireless and broadcasting facilities are available to issue instructions to the public, give warning about such matters as fallout, and to insure minimum needs in all vital fields of civil defence, both national and international. A special working party on warnings, established by the Civil Defence Committee, has completed international plans for transmission between the NATO countries of vital information and data in the event of nuclear explosions and for the prediction of fallout. The special committee which is examining all aspects of the problem of communications is the Civil Communications Planning Committee.

The primary responsibility of caring for casualties resulting from air or missile attack presents particularly difficult problems since in peacetime hospitals are normally situated in probable target areas, and would have to be transferred to temporary buildings or other hospitals situated in areas less likely to be attacked. A special NATO Medical Committee was set up to consider these problems and, since the whole hospitalization problem is a joint civil and military responsibility, worked closely with SHAPE. Having completed its studies, the Committee has been disbanded. Any specific medical problems are now dealt with by a special working group directly responsible to the Senior Committee.

In case of war, the authorities responsible for labour will have calls from all sectors of the national economy asking for every category of manpower. Legislation and organization are required for the control and allocation of such labour and for the establishment of priorities. In particular, highly qualified scientific and technical skills must be utilized to the greatest advantage. Study of these problems was undertaken by a Manpower Planning Committee, which provided the necessary guidance and has been disbanded.

In an emergency there will clearly be a need for international machinery concerned with both civilian and military needs. Under instructions from the Senior Committee, the International Staff and the technical Boards and Committees have prepared plans for setting up international Civil Wartime Agencies having the necessary links with the military authorities and, to the extent necessary, among themselves. The planning for these various agencies, which would be activated in an emergency, constitutes a substantial element in the work of all Civil Emergency Planning Boards and Committees. Plans have been and will be further tested in major logistic exercises. ▲

A BRIEF ON DISASTER PLANS

A Brief View on the Adequacy and Inadequacy of Disaster Plans and Preparations in Ten Community Crises

by
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Introduction

It is rare to find an American community today with a complete lack of disaster plans and preparations. However, when disaster strikes, many communities find that their plans and preparations are insufficient and in need of improvement. When community organizations have no practiced preparations which fit into an organized, overall disaster plan, response to the disaster tends to be too segmental, too limited in scope, and too much dominated by immediate tasks to provide efficiently for the more general, continuing human needs posed by a disaster.

It is the purpose of this brief paper to report findings about the adequacy and inadequacy of disaster plans and preparations in ten community crises in the United States. The ten cases have been selected from those studied by the Disaster Research Center (DRC) and include the following: (1) 1963 Indianapolis, Indiana Coliseum explosion, (2) 1964 Anchorage, Alaska earthquake, (3) 1964 Cincinnati, Ohio flood, (4) 1965 Wichita, Kansas plane crash, (5) 1966 Topeka, Kansas tornado, (6) 1967 Fairbanks, Alaska flood, (7) 1968 Jonesboro, Arkansas tornado, (8) 1969 Glendora, California flood and mud-slides, (9) 1969 Sioux Falls, South Dakota flood, and (10) 1969 Minot, North Dakota flood. These disasters range from a progressive, diffused type, the Fairbanks flood, to an instantaneous, localized type, the Wichita plane crash. Our goal is to provide the disaster planner with findings that can be applied in formulating approaches to alleviate disaster disruptions. Given the high degree of similarity between American and Canadian societies, it is anticipated that the findings from these ten American community crises will be of assistance and interest to Canadians involved in disaster planning.

The Findings

Our focus is upon the social-organizational rather than the physical or engineering aspects of disaster planning. We shall deal with disaster plans in terms of assessment of the crisis situation, communication possibility, community authority structure, interorganizational coordination, and general weaknesses of disaster plans.

Assessment of the Crisis Situation

In many communities the disaster plans do not assign an official or organization with the responsibility of assessing the situation to find out just what the overall emergency is and what it means. The typical response is for each organization to appraise the situation in terms of its own functions and needs, and then to retain the disaster information within the organization rather than sharing or pooling the knowledge on a community-wide basis. Disaster preparations seldom provide for systematic reconnaissance and other procedures for maintaining a central strategic overview of the crisis.

In Indianapolis, Anchorage, Fairbanks, Jonesboro, Glendora, and Minot the nature and extent of the damage to the community was not ascertained for a considerable period of time after disaster impact. However, this information was crucial and necessary in order to understand the overall dimensions of the tasks now facing the community. In contrast, disaster planning was more extensive in Cincinnati, Wichita, Topeka, and Sioux Falls and in these disasters knowledge about the number of dead and injured, the areas that were damaged, and the nature of the damage was more readily available.

Communication Possibility

The disaster preparations of a community frequently do not make any arrangements for emergency communications, and regular communication facilities are often inadequate or inoperative during a crisis. A large part of the disorganization which follows a disaster stems from the fact that normal methods of communication are often disrupted while the necessity for communication is increased. In addition, few disaster plans make any arrangements for disseminating disaster information to the community organizations, mass media, and general public. As a result varying and conflicting reports of the disaster sometimes arise and receive wide coverage

ABOUT THE AUTHOR

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through mass communication. Thus, two major types of communication problems arise in crises: (1) a lack of alternative means of communication, and (2) inaccurate communication content.

In Anchorage, Fairbanks, and Minot damage to telephone facilities and a lack of sufficient radio communication facilities resulted in inadequate communication during the crises. In comparison, the fire and police department radio communication facilities in Topeka and Sioux Falls were capable of handling a large volume of emergency communication, and in these two disasters, communication problems were minimal.

Inaccurate communication about the flood crisis did not occur in Sioux Falls as it did in Fairbanks, Glendora, and Minot. The disaster plans of Sioux Falls specified that a daily briefing should be held for all organizational officials and anyone else seeking disaster information. Such a briefing took place daily at the emergency operations center, and, in addition, all news releases were made by only two officials, the coordinator or assistant coordinator of flood activities. In contrast, the disaster plans in Fairbanks, Glendora, and Minot did not make provisions for such communication possibility.

Community Authority Structure

Authority procedures are not always apparent once a community has been struck by disaster. When authority is not operative, the response of community organizations frequently occurs outside a chain of command. In situations where overall control is lacking, the occurrence of disputes concerning authority, responsibilities, and jurisdictions is not uncommon.

Disaster plans sometimes fail to designate a legitimate source of overall control of emergency activities, and they thus contribute to a community authority vacuum or ambiguity concerning which official, agency, or organization has the authority to make crucial decisions during a crisis. This was the case in Indianapolis, Fairbanks, Jonesboro, and Minot. For example, the disaster plan in Indianapolis specified that civil defense should assume overall control when a state of emergency is declared, but it did not make explicit a source of authority in a situation such as the Coliseum explosion where no state of emergency was declared. The disaster plan in Sioux Falls, by way of contrast, indicated four alternative sources of authority: (1) mayor, (2) civil defense coordinator, (3) flood-control project superintendent, and (4) a long-time employee of the city light department. With this explicit definition of the chain of command, there was no ambiguity or lack of authority at any time during the flood crisis.

Few disaster plans make arrangements for the establishing of command posts at the disaster scene. Consequently, members of organizations involved in the disaster response have no one person or no central location in the field to turn to for advice and direction. This was the situation that developed in Indianapolis, Fairbanks, Jonesboro, Glendora, and Minot. In these disasters, officials of high rank and authority in the predisaster stage failed to set up command posts and exercise authority and leadership in the disaster system. Rather, they became directly involved in such activities as search and rescue, transportation of casualties, and traffic direction. In contrast, in Wichita and Topeka high-ranking organizational officials immediately set up command posts at the disaster sites, and thus insured overall control and command of disaster operations.

Interorganizational Coordination

Most of the problems of disaster originate in the lack of coordination among the many groups and organizations, each of which is viewing and attempting to meet the needs of the disaster in terms of its own perspective and capabilities. The immediate problem in a disaster situation is neither uncontrolled behavior such as looting nor intense emotional reaction such as panic, but deficiencies of interorganizational coordination. It is often the case that allocation of resources is decentralized to a large number of organizations, each under pressure to act quickly and directly, and little or no attention is given to the linking of these resources by spanning the boundaries of the organizations. Most organizations involved in large-scale disasters lack predisaster understanding as to the scope of their activities and the necessity of coordinating their activities with one another. Specific organizations show some hesitancy in seeking coordination with others or assuming the responsibilty themselves since it is seldom seen as being an inherent or traditional function of any one community organization.

Some disaster plans facilitate interorganizational coordination by arranging for the activation of an emergency operations center during a time of crisis. The plans frequently call for a representative from each key emergency organization to function from the center or at least for organizational representatives to attend community-wide meetings at the center. At these meetings representatives from the various involved organizations usually present reports of their respective activities. Through these reports each organization becomes aware of what other organizations are accomplishing, and consequently omission or needless duplication of crucial tasks is minimized. Problems arising during daily operations are considered at the meetings and generally through discussion a consensus is reached resolving the problem. Plans of action are frequently discussed and formulated.

In Cincinnati, Topeka, and Sioux Falls preplanning for an emergency operations center had been undertaken, and in these communities, these centers became functional and there was overall coordination and direction of organizational efforts throughout the crisis. In a number of other disasters, Anchorage, Fairbanks, Jonesboro, Glendora, and Minot, a centralized, coordinating center did not exist at the beginning of the disaster primarily because of the lack of adequate and up-to-date

preplanning. Thus, in the early stage of these crises, there was organizational atomization of the emergency response with community organizations carrying on their disaster activities independently of each other.

Some General Weaknesses of Disaster Plans

Disaster frequently creates new tasks of undeniable immediacy which must be accomplished if the community is to continue to exist and function as a viable entity. These tasks are seldom anticipated and considered in disaster plans, and thus there is usually no prior assignment of organizational responsibility. For example, search-and-rescue activity is not often considered the major responsibility of any existing community organization. The task of information clearance is one which is usually not previously routinized within a community and often several organizations assume this task with conflict and confusion ensuing. Other disaster-generated tasks that are commonly unassigned include inventory of existing resources such as available food and fuel supplies after disaster impact, feeding and sheltering of refugees, issuing of access passes to the disaster area, control of vehicle and pedestrian convergence, effective use of volunteers in ongoing operations, and transportation and feeding of volunteers and disaster workers. In order to have an agreed upon, understood division of labor among different groups and organizations in disaster, disaster plans should take into account and assign the tasks that commonly occur in community crises.

Many communities prepare for a specific type of disaster such as a nuclear catastrophe when drawing up disaster plans, and preparations for nuclear disasters and other peacetime crises are often neglected. Consequently, when disaster strikes, the existing disaster plans may be inappropriate. This was the case in both Anchorage and Minot where the disaster plans and preparations were oriented toward a nuclear explosion, and could not be easily adapted to the earthquake and flood crises.

Disaster plans also frequently remain in the "paper" stage and are not rehearsed in simulation exercises. Through lack of practice gaps in the plans and ineffective aspects in disaster preparations remain undetected. These quickly appear in the time of disaster and crucial time must be taken to make compensations for the inadequate "paper" arrangements. When there is a lack of rehearsals, there is also a general lack of familiarity with existing disaster plans and preparations, and yet effective plans must be understood and accepted by all those who have a part in them, including the general public. In Topeka, for example, yearly disaster simulations are held to coincide with the beginning of the tornado season, and in this community the disaster plans were very effective during the tornado crisis.

To be effective disaster plans must be subjected to regular review and revision. All plans have to be up-to-date to be of optimum use and value in coping with a crisis. It is not unusual for disaster plans to be of limited value during a crisis because they have not been given any attention since the time they were first formulated. This situation existed in Indianapolis and Jonesboro where disaster plans and preparations had been neglected for a period of years, and as a result lists of available equipment and names and phone numbers were outdated.

Finally some disaster plans stress the physical aspects of disasters and pay insufficient attention to the social-organizational aspects of disaster response. For example, in Glendora, in preparation for flooding, sandbags had been stored in accessible locations and dykes and plywood barriers had been erected throughout the community. However, the plans and preparations were not adequate since no arrangements had been made for overall coordination of these disaster activities and for inter-organizational communications. The scope of disaster plans should be sufficiently broad to encompass the social-organizational as well as the physical contingencies of disasters.

Conclusion

We have through the consideration of ten disasters studied by the Disaster Research Center attempted to identify some of the recurrent problems in disaster planning. Our underlying assumption has been that knowledge of what actually happens during disaster response is requisite for effective planning for community disasters.

The findings bear testimony to the need for large-scale disaster planning, and at the same time they should contribute to a more satisfactory basis for such planning. In other words, we hope the findings by pointing out the adequacy and inadequacy of some existing plans suggest directions that community leaders may take in planning to meet disasters effectively.

It is further hoped that the findings will contribute information and offer guidance to increase the efficiency of efforts to minimize destruction and to restore necessary facilities in disaster areas, and thus make a contribution to national survival in the event of a nuclear war. We have not, however, endeavored to extrapolate our findings to thermonuclear situations. Perhaps after further study of peacetime disasters attempts can be undertaken to extrapolate findings from completed disaster studies to a kind of disaster that is difficult to envisage.▲

CD Little Harbor Report — Part Two

The first five chapters of this 1969 report to the U.S. Atomic Energy Commission by a Committee of the National Academy of Sciences were published in the preceding June-July 1969 edition of the Digest. The following three chapters complete the report.

Education and Training

The education and training program in civil defense has five objectives: (1) professional education of full-time civil defense executive and staff personnel; (2) informing and orienting the general public; (3) providing operating experience to local government officials; (4) training personnel who have emergency and recovery duties related to their regular jobs; and (5) making people in technical professions aware of the objectives and problems of civil defense. Many of these programs are active now and are discussed here for support and emphasis. We propose modification and expansion of some.

1. Professional Education of Full-Time Civil Defense Executive and Staff Personnel

Thorough professional competence of full-time civil defense officials is vital to the success of all facets of civil defense planning and operations. It is also essential for the acceptance of civil defense programs by state and local officials and related federal officials whose responsibilities affect, and should be affected by, civil defense. Adequate coverage of this need can be provided by: (a) a preparatory orientation and training program for professional recruits; (b) a command and staff school to prepare personnel for advancement and executive responsibility; (c) a planning staff associated with the command and staff school to contribute to developing a coherent doctrine and the operating policies and procedures for civil defense. The recommended command-staff school is essentially identical to the Civil Defense Institute recommended in the original Harbor Report.

In its training activity, the command-staff school should provide instruction to those who can be expected, by inclination and previous training, to devote at least a major part of their careers to the tasks of the civil defense organization and to assume important functions therein. The planning staff could do most of the instruction, thereby remaining in close contact with new civil defense officers and personnel. An intimate contact between the staff of the school and the Director of the Office of Civil Defense is most desirable. Possibly, the OCD Staff College in Battle Creek could, after considerable expansion of its facilities and personnel, fulfill this function.

2. Informing and Orienting the General Public

Should civil defense emergency and recovery measures ever be required by an actual nuclear attack or should an advanced state of readiness including civil defense measures ever be ordered during an international crisis, these measures will be effective in greater or lesser degree depending on how well the general public, especially the urban public, is informed about them. To reach the state of having an adequately informed public will require a long-term and continuous effort. The principal means of informing the public are: (a) job or common-interest group orientation through employers, unions, parent-teacher associations, and similar organizations; (b) adult education, including general orientation and practical instruction; (c) public education in secondary school and college and college curricula; and (d) general information disseminated by the mass media.

3. Providing Operating Experience for Local Government Officials

Civil defense emergency operations and recovery activities usually will be largely in the hands of local officials. These officials, particularly those who man local control centers, should have training to enable them to form an operating organization. Since actual situations cannot be experienced in the course of the training, realistic simulation, as used in command-post exercises or army field maneuvers, should be provided. The following steps may be necessary: (a) acquaint personnel who may be called upon in a real emergency with the methods of simulation training — this is the training procedure in which they react to messages similar to those they would receive in an actual attack, and their reactions are discussed and analyzed afterward; (b) prepare packages containing simulated messages of the kind described which are adapted to local conditions; (c) devise a program for the gradual expansion of simulation training from locally centered through regionally oriented to nationally integrated exercises, including coordination of civil defense exercises with the NORAD "Desk Top" exercises.

4. *Training Personnel Who Have Emergency and Recovery Duties Related to Their Regular Jobs*

During an emergency most of the working-level personnel of the civil defense effort will come from state and local organizations, such as police and fire departments, whose full-time duties in peace time include reacting to civil emergencies. These agencies will be supplemented by their own auxiliaries and other local volunteer organizations. The next source of supplementation is the National Guard; and the final recourse, as far as people can be identified by organizational affiliation before the emergency, is the federal forces, such as military units, that are located nearby. All personnel from these sources have training relevant to emergency operations, and they are organized to apply this training. To render them effective for coping with the problems that may arise from a nuclear attack, they should be given supplementary training in specific civil defense functions, such as radiation monitoring and reporting, and use of shelter facilities, of stocks in shelters, and the like. Not only such local organizations as police and fire departments, but the National Guard and the Army Reserve units also should undergo training in these subjects. We have recommended that the Continental Army Command, which has responsibility for training Army personnel for civil defense functions, make civil defense training part of the basic training of all armed forces.

Some of the personnel in each of the above categories should be qualified as instructors so they may continue to give courses in their own organization and to instruct shelter occupants in basic nuclear hygiene, recovery procedures, etc.

A Department of Defense directive (No. 3025.10, dated Apr. 23, 1963) established general guidelines for military support of civil defense and assigned the major responsibility to the Continental Army Command. During the five years since the directive was issued, much progress has been made, and at present the Adjutants General of every state have been assigned small planning staffs to assist them in the development of a state plan for the use of military personnel to support local civilian authorities during a civil defense emergency. This program has the potential for ultimately providing a real operational capability for civil defense throughout the country, and it should therefore be encouraged and strengthened.

The preceding proposals constitute, perhaps, the most significant departure from the recommendations of the original Harbour Report. They advocate training existing personnel of certain state and local organizations for civil defense functions and relying on these persons to a very large extent in case of emergencies, rather than depending on a large, full-time (single-purpose) civil defense force.

5. *Making People in Technical Professions Aware of the Objectives and Problems of Civil Defense*

A number of technical professions are particularly relevant to either civil defense operations (e.g., medicine) or civil defense preparations (e.g., architecture and engineering). The short courses and training programs that have been organized by the OCD Staff College can provide special knowledge concerning thermonuclear war and the problems of civil defense in coping with the direct effects of nuclear weapons and the procedures of recovery. With this type of knowledge, technical professionals can use their expertise to help solve civil defense problems.

Acceptance of Civil Defense Programs*

If a civil defense program were developed without regard for its image and its impact, the resulting program would lack the motivations, beliefs, attitudes, incentives, and expectations that are needed to support it; it would not serve the goals, aspirations, and values which it is supposed to further. These larger considerations are outside the scope for explicit consideration in most civil defense studies and plans, but they are of decisive importance in judging the realizability and desirability of a civil defense program.

In an attempt to assess the probability of acceptance of civil defense programs, both what is to be accepted and what is meant by acceptance must be specified.

The minimal characteristics of what is to be accepted are (1) the existence of a threat whose severity, probability, and timing deserve the defensive efforts proposed and (2) a program, as well as a goal, which is sensitive to changing conditions and which will reduce the threat or ameliorate its consequences at a cost and with a level of effectiveness and consequent benefits that merit the program's implementation. The civil defense program should be closely adapted to the changing character of the threat since the interaction between the two is part of the situation to be accepted. Just as with other strategic programs, the civil defense program should not, either actually or in appearance, significantly increase (a) the incentive for another nation to attack, (b) another nation's fear of being attacked, or (c) the development of countermeasures that escalate the cost of defense without significantly altering the balance of deterrence or level of security.*

Acceptance is not so much a simple attitudinal matter, i.e., attitudes of liking, interest, or even confidence, but rather: (1) a belief in the existence of certain conditions

*No need was found to update or otherwise modify the conclusions of the Project Harbor Summary on the subject of impact, i.e., impact outside the context of national strategic posture.

of threat; (2) an understanding of the consequences of possible responses; and (3) an assignment of sufficient priority to those actions that implement the program for ameliorating the threat.

Widespread belief in, and understanding of, situations in which many characteristics are changing and changing each other is difficult to secure. If belief and understanding are achieved among opinion leaders, however, more general belief and understanding are hastened. Furthermore, a shift in assigned priority of action is required initially only of decision makers,† i.e., those who initiate, plan, decide, budget, and the like. They are a very small segment of the population, but the larger public, given the supporting belief in conditions, and faith that the decision makers have understood the consequences of responses, will correspondingly shift its priorities. The likelihood and extent of acceptance are increased therefore if a decision maker (1) increases the credibility of the assessment of the threat; (2) clarifies thoroughly the implications of the possible responses; (3) restricts the pace of required change in currently accepted priorities; (4) restricts the number of people whose direct participation is required; and (5) minimizes the resource commitments made necessary.

A program to fit such a set of conditions is not easy, and it will be relatively slow; but it should have a better image than a coerced rapid preparation for facing an attack. Given enough time, it should also be more effective.

Experience of the Office of Civil Defense in the interval since Project Harbor indicates that the problem of acceptance of civil defense by the public is not as serious as it was once thought to be.‡ Mail returns from householders in several states on a questionnaire asking for information on their homes with a view to evaluating and adapting their basements as shelters ranged from 73 to 85%. Such a remarkably high response is hardly indicative of apathy. Experience with shelter licensing shows that among building owners and managers only 3% refuse to make their property available because they are opposed to civil defense, indicating a high degree of acceptance of at least this facet of civil defense. The problem of acceptance appears to lie more with opinion leaders than with the general public and with various aspects of the program rather than its overall value. Opinion leaders are mostly sensitive and thoughtful people, and many hard questions must be considered regarding civil defense. Many interdependent and conditional factors affect civil defense and its effects. Even the physical nature of the threat is uncertain: if one prepares for fallout, the threat shifts to blast; if for blast of a given magnitude, then the magnitude increases. If one prepares to evacuate and stockpiles for industrial recovery, the enemy may be impelled to strike first. If a program is hurried, how is it interpreted? What gives it such priority? If it is slow, is it sufficiently effective? If it is big, is it worth the cost?

In a system of conditions so evasive of control, simplification is a necessity, though fraught with the danger that simplification may turn out to be oversimplification. Most people will fix on one or another point or principle to eliminate some of the interactive complexity from detailed consideration. Each of these simplified points is then regarded as a fixed assumption or basic tenet by some people; for others the points will still be open to debate and examination. Examples of such points are (1) there is certain to be a nuclear attack some day, some place; (2) if we are peaceful, we never will be attacked; (3) becoming as strong as possible is a national duty; (4) a strong United States is as great a menace to peace as any other strong country can be; and (5) saving lives is worthwhile even if postattack conditions are unclear or unmanageable; (6) civil defense cannot help but make war more likely; (7) postattack conditions will be manageable; (8) protection must completely eliminate differences in risk among people; and (9) certain values are eternal and must be defended against any attack no matter how severe it is.

Acceptance is, of course, impeded by adherence to some of these points and enhanced by adherence to others. If a civil defense program is a defensible component of our national strategic posture, critical dialogue will gradually expose oversimplifications and will lead to acceptance of civil defense on a sound basis of understanding.

In the light of past and proposed programs of civil defense, one can list the following factors that inhibit acceptance of civil defense:

1. The seriousness and unattractiveness of the conditions that have to be considered.
2. Past confusions, disputes, and low evaluations regarding certain civil defense programs.
3. Unrealistic images and inflated figures on the value of certain civil defense programs.
4. Optimism about, and interest in, other more dramatic programs.
5. Contesting rival priorities for political attention.
6. The dullness of many of the behaviors required in passive, unused, standby civil defense programs.
7. The lack of immediate utility of the types of behavior required by civil defense programs.
8. The extremely dynamic nature of the continuing dialogue on national defense and international relations.
9. The low level of official attention to the assessment of the impact of civil defense on the balance of deterrence and the cost of national defense.
10. Apprehension about side effects, i.e., peacetime effects of civil defense on the nature of American society.

*These considerations play a major role in the chapter on Threat.

†Note that decision makers are often among the opinion leaders, but there are many more opinion leaders than decision makers.

‡The research of Professor Jiri Nehnevajsa at the University of Pittsburgh also substantiated this point.

The following factors contribute to the acceptance of civil defense programs:

1. A program tied to a total, long-term threat and not merely to a particular crisis or a single opponent nation.
2. A program that emphasizes a character for civil defense that is non threatening to other nations.
3. A program based on assumptions that are both sound and plausible even though not attractive.
4. A graded, slowly evolving program of increasing utility and protection that can be sensitive to local and international conditions.
5. Federal collaboration with state and local governments to assimilate civil defense into continuing state and local government operations.
6. Professionalization and specialization of civil defense tasks and services.
7. A program that sets some of its priorities by planning for a combination of usages that contribute to other desirable objectives and programs, both governmental and private.
8. Dual use of personnel, as well as facilities, instead of a specialized, unused, standby cadre.
9. Measures combatting the threat of a military attack and natural disasters and also responding to social needs under noncrisis conditions.

The Threat*

Introduction

This chapter is a reexamination of the conclusions of the Harbor Project concerning the circumstances under which nuclear war may occur. In addition, it comments on some studies that have been conducted to determine the relative effectiveness of countermeasures against various levels of attack,† and it attempts to assess the relation of civil defense to other damage-limiting systems.

Evaluation of Threats

We concur in the conclusion of the original Harbor Report that any general war is likely to be preceded by a buildup of tensions, possibly even limited military action, which would provide days to months of strategic warning. Nevertheless, massive surprise attacks cannot be ruled out completely.

Although our committee views the USSR as the primary threat, China is a potentially hostile nation that shows growing nuclear capabilities; there may be others in the future. We are also concerned about nuclear blackmail because it may become a threat to our freedoms and principles whether or not it ultimately leads to war. The question of how a civil defense capability affects it should be examined further.

When assessing future threats one must take into account (1) the likely advance in weapons technology and probable improvements in missile systems, (2) the opportunity for protection through shelter and active defense, and (3) the possible impact or reaction that such defense, both active and passive, is likely to have on enemy objectives and tactics.

The effectiveness of future weapons and the capabilities of shelters to withstand various weapon effects are reasonably well understood and have been discussed in the preceding chapters. However, the complementary or competitive role of shelter and ABM systems is not adequately understood. Nor have probable enemy responses to shelters and ABM's been well explored. The committee considers further examination of these questions to be an urgent and important national task.

Cost-Effectiveness Studies

Opposition to civil defense programs has often been motivated by the presumed reaction of potential enemy nations to such programs. The following is a typical assertion of the futility of civil defense measures against the initial effects of nuclear weapons:

> Within the framework of the concept of deterrence, civil defense simply does not make sense. It is not an efficient way of spending the deterrent dollar. In the calculus of weapons systems and their effect upon an enemy's intentions, we can obtain more of an impact by spending our money for retaliatory weapons of our own. Dollar for dollar, the aggressor who is intent upon the massive annihilation of people can almost surely keep ahead of the pick-and-shovel work of moving underground for passive defense.

What does it cost to shelter people, and what does it cost the attacker to kill people, sheltered or unsheltered?

In the Immediate Survival chapter, estimates of the average cost per person for blast shelter in an austere single-purpose system (a 1,000-space shelter at 10 sq. ft./space, built on publicly owned property) were:

	Blast level, psi		
	15	50	100
Cost/space	$240	$270	$300

The cost per person to the attacker depends on (1) the cost of a delivered weapon, (2) the hardness of shelters, and (3) the density of the sheltered population.

*Dr. Winter believes that a very substantial expansion of civil defense and other preparedness programs is consistent with a national strategy that primarily emphasizes the deterrence of nuclear war and that such an expansion would be undesirable if it were not so consistent. He further holds that the rational case for preparedness is, in the words of the chapter on Acceptance, "tied to a total, long-term threat and not merely to a particular crisis or a single opponent nation" and that it should emphasize the wide range of contingencies in which the United States might suffer attacks by forces smaller than the full strategic arsenal of a strong nuclear power. Much of the Threat chapter, and points five and six of the chapter on Changes in Strategic Outlook, appear to him to be incompatible with these views, and he would accordingly like to note his nonconcurrence in those portions of the report.

†The Little Harbor Study, when concerned with level of hypothetical attacks, used 2,000 to 4000-Mt-attack studies, except for ecological consequences where attacks up to 12,000 Mt were considered.

The cost and 10 years maintenance of a 1-Mt nuclear warhead and its rocket delivery system is about $9 million, that of a 10-Mt warhead is about $50 million. If we consider an air burst to maximize blast overpressure, the areas covered by various levels of destruction are:

	Blast level, psi		
	15	50	100
Area covered* by 1-Mt explosion, square miles	10	2	1
Area covered by 10-Mt explosion, square miles	46	9	4

A typical population density in cities is 10,000 people per square mile, e.g., the density in the District of Columbia is slightly more than 12,000 people per square mile. If the density of population is 10,000 per square mile and the cost is $9 million for a 1-Mt weapon delivered, the cost of causing a fatality or a very serious injury at the various levels of blast resistance becomes:

	Blast level, psi		
	15	50	100
Cost/person	$90	$450	$900

These costs are directly proportional to weapon costs and inversely proportional to population density. Hence, only where the population density exceeds 30,000 persons per square mile does the cost of destruction drop below the cost of the 100-psi shelter ($300/person). The comparison is even more favorable if the enemy uses 10-Mt weapons costing $50 million each.

In 1975 the number of U.S. citizens expected to be living at densities exceeding 30,000 per square mile can be read off Figure 1.*

It is 6 million, and they are expected to live on a land area totaling only about 150 square miles. To attack them effectively in 100-psi shelters would cost the attacker more than 150 1-Mt weapons, or about $1.4 billion. To shelter them would cost us $1.8 billion. In other words, if a determined enemy were to choose to attack this denser part of the population (less than 3%), the cost to him would still be comparable to the cost of shelter.

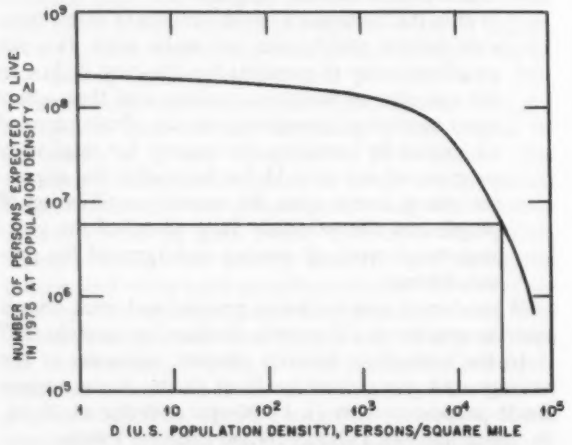

Figure 1.

*This assumes air bursts to maximize coverage but nonideal surface (city) conditions, which reduce blast somewhat from that on ideal surfaces.

*We are indebted to the Stanford Research Institute for the data of Figs. 1 and 2. See also the report of their Missile Defense Analysis Project: 1960 Population of the U.S. by 5-km Quadrangles, Rev. Ed., August 1965.

Interpretations of Cost Calculations

The preceding cost comparisons are incomplete in at least two respects. First, they consider fatalities as the sole measure of damage caused by enemy weapons and disregard damage to residences and industrial installations. Second, they assume that the enemy would be directed against those who are protected by blast shelters. It does not seem reasonable to assume that 100-psi blast shelters will be built for all people of the United States (over 200 million). That endeavor would cost about $60 billion. If not all the population is sheltered, the attacker may direct some or even most of his weapons against those who are not protected to cause the greatest number of casualties. Consequently, the ratio of the cost of shelters to the cost of their destruction for a specified density of population is not as meaningful as the number of casualties that can be inflicted on the country as a whole against a defense costing a certain amount, by an offensive capability involving (a) the same expenditure and (b) the same expenditure in addition to that already made.

When making these calculations, the committee disregarded a number of factors which would alter the number of casualties that are to be feared. Factors that would lower estimates of casualties are (1) evacuations to decrease the number of people in areas of high population density, (2) the fact that the enemy can hardly be expected to use all its weapons for antipopulation attacks, and (3) the most important, that the ballistic missile and air defense would reduce the weight of the attack. As mentioned before, ABM systems can be counted upon to cause modifications of the enemy's weapons, which will result in a reduced effective explosive power. On the other hand, we assumed that all the people, including the rural sections, would be protected against fallout, i.e., that something similar to the full fallout-shelter program had been put into effect. We assumed, also, that there would be sufficient warning time for the population to take advantage of the shelters. Although in most circumstances more than enough time would be available, sufficient warning time would be more difficult to provide for the worst, but unlikely, case of a massive sudden attack not preceded by some developing crisis. For making optional use of the shelters in case of a sudden attack, they would have to be so arranged and the warning system so designed that people could reach shelter before an attack with intercontinental missiles arrives. Such an arrangement of shelters and a corresponding warning system appear to be feasible. However, even the installation of the fastest warning system and the most suitable shelter arrangements con-

sidered so far would not be effective against a missile attack launched from submarines. The flight time of missiles from submarines lies in the range of 5 to 10 minutes. Of course, much of our military intelligence effort is aimed at anticipating just such surprise attacks.

We have calculated the approximate number of fatalities that can be inflicted on the country as a whole by an attack with 10-Mt missiles costing as much as the shelter system to be postulated. As will be seen from the tabulation, the range of nuclear weapons for creating casualties in the absence of blast shelters plays an important role. Since we assumed that fallout shelters are available to everyone, the range can be expressed in terms of blast pressure. The calculations were carried out under the assumption that the mid-lethal range is that where the blast pressure has dropped to 15 psi. Even this limit is valid only if some protection, such as hasty shelters, can be assumed in addition to the fallout protection. Two alternatives were considered: (1) that every weapon finds its target and (2) that only two-thirds of them do. The latter is the customary assumption and takes care of duds and various kinds of malfunctioning of the propulsion and guidance systems. It does not account for the effect of ABM.

The calculations that follow are based on the population distribution expected for 1975 and represented in Figure 2. The squares referred to in the abscissa have sides 5 km long and hence an area close to 10 square miles. The squares are arranged in order of decreasing population density so that, for instance, the first 100 squares contain as much population (about 22 million people) as any 100 squares, 5 km by 5 km each, contain. The ordinate represents the aggregate population. Thus, as implied above, the 100 most densely populated 5 km by 5 km squares will contain, according to the figure, a total of 22 million people in 1975. The calculations also assume that the enemy uses 10-Mt weapons costing $50 million each. This may be a higher cost than would correspond to $9 million for 1-Mt weapons. It was assumed, further, that all people living in areas with a population density in excess of 5,000 per square mile would be provided with blast shelters, i.e., 76 million people, at a cost of $22.8 billion. If the enemy spends the same amount of weapons, he would have 456 of the 10-Mt weapons. His targeting was assumed to aim at causing the maximum number of fatalities. This will be the case if he uses air bursts rather than surface bursts, which, on the other hand, would minimize the total fallout to be expected. The estimates of the fatalities, in millions of lives, are given in the table that follows for five alternative targeting methods of the attacker: reading the columns from left to right, the attacker explodes 100%, 75%, 50%, 25%, or 0% of his weapons over areas protected by 100-psi blast shelters, the rest over unprotected areas.

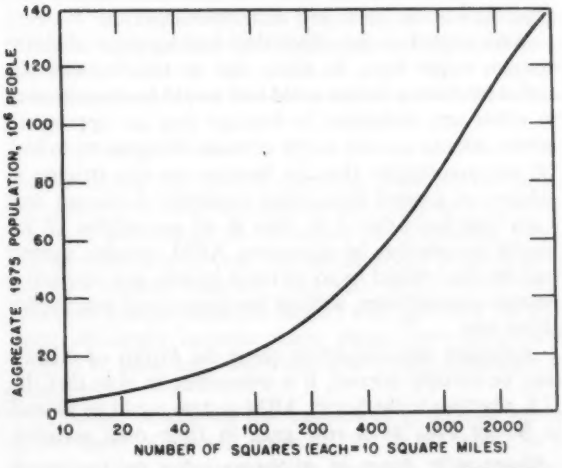

Figure 2.

To obtain the first number of the table, one observes that 456 weapons can create a pressure of 100 psi or more over $4 \times 456 = 1{,}824$ square miles, or about 182 units of the diagram (Fig. 2). This figure then shows that the population in the area covered amounts to about 32 million people. To obtain the figures of the second column, one has to note, first, that the 76 million people who are protected by blast shelters live in the 810 most densely populated squares. Since 114 weapons can cover an area of $114 \times 46 = 5{,}244$ square miles, or 524 squares, the enemy will aim them at the squares numbered 810 to 1,334. The total population in these squares is 97½ — 76 = 21½ million. To this number must be added the fatalities caused by the 342 weapons exploded over areas with blast shelters. These can cover $342 \times 4 = 1{,}368$ square miles, or 137 squares. According to Fig. 2, there are 26½ million people in these squares; so the total fatalities would amount to 21½ + 26½ = 48 million people.

Naturally, the calculation is approximate, but it does give an orientation. More accurate calculations, taking various other factors into account, give values only a little different — about 10% lower. The losses calculated for the case in which both offense and defense spend $10 billion are quite similar. High as the calculated losses are, they are only fractions of those which can be expected in the absence of effective shelters.

	100%	75%	50%	25%	0%
Weapons against areas with blast shelters	456	342	228	114	0
Weapons against areas with fallout shelters	0	114	228	342	456
Fatalities (millions) if all weapons explode as aimed	32	48	56	56	53
Fatalities (millions) if two-thirds of weapons explode as aimed	24	33	38	38	37

The preceding tabulation gives the fatality numbers for an equal expenditure of offense and defense, if this expenditure is around $22½ billion. This is not, however, the point at which the defense expenditure is equal to the cost increase of the offense necessary to maintain the same damage that could be caused in the absence of blast shelters. To cause 56 million fatalities, the attacker has to destroy, even in the absence of blast shelters, 460

unit squares of the diagram for which he needs, in the absence of blast shelters, 100 weapons of 10 Mt. The cost of these is $5 billion, which is small compared with the $22½ billion here under consideration. This calculation assumes that all weapons find their target. The result, however, is insignificantly different under the assumption that only two-thirds of the weapons are effective.

In summary we can say that in the absence of active defense and assuming equal expenditures for offense and civil defense, the offense against the United States could be expected to cause in 1975 the loss of around 50 million lives if it were directed solely against the population. The loss of life would be lower if some active defense were available, if some of the attack were not directed against the population, or if the expenditures for civil defense exceeded those of the offense. The loss of life would be larger if, in the absence of active defense, an attack involving a larger expenditure on weapons than our expenditure on civil defense were undertaken against the U.S. population.

Policies of Deterrence and of True Defense

Cost effectiveness studies cannot provide a complete comparison of civil defense and of active defense measures with measures of strategic defense (threat of retaliation). The reason is that the comparison must involve some judgment concerning the behavior of enemy leadership, and there is no objective way to arrive at such a judgment. History shows that the leaders of nations can, and often do, act irrationally. Since reliance on strategic defense and the doctrine of assured retaliation presupposes some rationality on the part of the leadership of potential enemies and since this cannot be completely relied upon, it is prudent to provide some positive protection to the people in addition to the threat of revenge. The value of a shelter system can be calculated in terms of lives saved in a nuclear attack of given size; the value of assured retaliations is subject to great uncertainty.

In long wars or during extended periods of tension, evacuations and relocation of the population can greatly reduce the loss of life. The Soviet literature discusses major evacuation plans extensively. Recent studies in the United States point to a variety of circumstances in which evacuation, coupled with the use of improvised shelters, would be the most effective life-saving measure. There are inherent difficulties in planning these actions for purposes of defense because their effectiveness is too dependent on the timing and severity of the attack.

Nuclear Blackmail

The mere ability of a nation to wage nuclear war enables it to use threats and ultimata to achieve political advantage over another country. Potential aggressors can be assumed to be familiar with the tactic of repeatedly exacting small concessions under heavy threats. The threat would be particularly effective if it were made in conjunction with the evacuation of major cities and the sheltering of their populations.

The committee believes that the tactics of nuclear blackmail must be seriously considered in relation to civil defense. We can only speculate on what the United States could do if a strong nuclear power demanded concessions, such as U.S. withdrawal from West Berlin or abandonment of the Philippine Islands, and then started to evacuate its cities. If the United States conceded, would the aggressor repeat these tactics? Would U.S. retaliatory power remain effective if the threatening nation through evacuation reduced its population density from 5,000 to 1,000 per square mile, particularly if the evacuated people were protected by blast shelters? Would the counter threat have to be directed against industrial facilities instead of against masses of people? Would that be an adequate deterrent?

The ability of the United States to extend protection to its people would greatly reduce the likelihood that nuclear blackmail would be attempted against this country; it would also affect the probable success of such blackmail. Some of the committee believe that these effects could be of decisive importance; all of us felt that the underlying questions should be carefully studied.

If protective measures are to decrease the threat of nuclear blackmail, they must not aggravate the crisis. Such aggravation will be avoided if the movement to shelters could take place within the tactical warning time. If this is the case, shelter taking by some will not weaken the enemy's bargaining position; those who have gone to the shelters could have gone there anyway after the attack had been launched. Hence, early shelter taking would not tempt the enemy to precipitate action because it would not weaken his bargaining position.

ABM and Deterrence

The position of the former Secretary of Defense on the question of the relative importance of deterrence and damage-limiting effects, principally the ABM, has been that "capacity for 'Assured Destruction' must receive the first call on all our resources and must be provided regardless of the costs and difficulties involved."*

With regard to the effect that development of ABM systems might have, he states that he believes that our active retaliatory forces could and would be strengthened to offset any reduction in damage that an opponent's active defense systems might achieve. He goes on to say, "If our assumption that the Soviets are also striving to achieve an assured destruction capability is correct, and I am convinced that it is, then in all probability all we would accomplish by deploying ABM systems against one another would be to increase greatly our respective defense expenditures, without any gain in real security for either side. . . ."

Although this conjecture about the futility of ABM's may be entirely correct, it is interesting to note that the U.S. reaction to the Soviet ABM system could be viewed in Soviet eyes as a real gain in their own security.

*Statement by Robert M. McNamara before the Joint Senate Armed Services Committee, January 23, 1967.

Changes in U.S. strategic forces to improve missile penetration aids and to develop new reentry vehicles specifically designed for use against targets heavily defended with ABM systems have been announced. To the extent attention has been turned from encompassing more Soviet targets to attempting to maintain a capability to strike important ones, the Soviets have gained.*

The existence of an ABM forces the attacker to reduce the fraction of missile weight devoted to nuclear explosives if he plans to increase the chances of penetration. Installation of even a modest ABM system increases the effectiveness of shelters because it reduces the total weight of attack possible at a given expenditure.

The Development of Planning Assumptions

The establishment of sensible protective measures by individual communities requires the definition of the threat likely to be faced in the event of attack. Although precise conclusions on enemy targeting and attack plans are not possible, an important role for federal authorities is to make available to individual communities reasonable and applicable assessments of local risk. Assumptions on levels, types, and objectives of enemy attacks and the specific degree of blast and fallout protection to afford reasonable prospects for survival, should be developed and made usable for communities and individuals to guide them in planning civil defense actions. Areas around the most likely targets should be made aware that their risks are relatively great and the protection against initial effects is called for; areas far from targets should be advised that their risks will probably involve only fallout.

Finally, we note that in response to growing Soviet capabilities the Department of Defense is providing high-quality blast shelters for our missile systems and is discussing the deployment of NIKE-X for their added protection. The same Soviet capabilities pose a hazard to human lives which will be alleviated to a modest degree by the thin ABM system now in the planning stage. Civil defense measures could lessen the hazard much further. ▲

*The reduction of the total explosive power carried by our own missiles was spelled out by Paul Nitze in his statement to the Joint Committee on Atomic Energy, on November 7, 1967.

NORTH AMERICAN AIR (*continued from page 7*)

bomber, perhaps they will not get into a large increase in the anti-bomber competition.

They would like to provide a completely mobile air defence package, and this is primarily because the United States wishes to be able to conduct air defence operations in other parts of the world on fairly short notice and to be able to deploy the system widely.

The importance of Canadian Geography

I think in completing this briefing I should say something about the peculiar advantages of Canadian real estate in air defence of North America. It has been fairly clear from what has been said, I think, that it is important to extend this system outwards. As far as the inhabited area of North America is concerned, outwards means east over the Atlantic and west over the Pacific, but northward has to be over Canada. Many square miles of real estate or of air space are needed in order to make a system like this work. It cannot be done in a thin layer.

If we are going to have aircraft operating many miles to the north, it is, of course ,more efficient to have them based fairly near the operating area, otherwise they expend a good deal of their fuel and endurance time in simply flying out to the job rather than doing it. I think it is clear that Canadian geography would have an important part to pla yiyn a really efficient deep air defence system.

As far as the positioning of radars goes, there is this problem about the Aurora and whether a certain type of radar would work as well in Canada as elsewhere, and I think research is needed to find out more about that.

When we are discussing the North American air defence problem, we have to realize that we do own a good deal of the territory over which it will have to be done if it is going to be done very well. That, I think, is a fact that is unlikely to change as long as there is an air defence. ▲

SOIL (*continued from page 9*)

ination unless that level is excessive. Methods of washing, peeling, dehusking, milling and shelling employed for food preparation in the home or processing plant will remove in large part any radioactivity present, providing it is done carefully and with an excess of non-radioactive pure water. A factory will probably do this more efficiently because many plants have their own sources of pure deep wellwater and a built-in sanitation program.

A simple processing line capable of producing up to 2,500 cases of canned potatoes (19 ounce pack) in a five-hour day will serve as an example. The potatoes are moved by truck to the plant, dry brushed to remove soil, screened to remove stones and mechanically sized. They are washed and blanched with mechanical peeling followed by another washing. The product is put in salt water in cans for sealing.

Research is finding solutions to some of the problems associated with radioactive fallout in agriculture, but it must be stressed that there are still more problems than solutions. It is doubtful that man will solve all of the problems involved with agricultural production following a major nuclear confrontation. There is, however, enough knowledge available today to make it possible to feed all the population after a nuclear war—and to feed them a diet that is both adequate and wholesome. ▲

U.S. VIEWS ON CIVIL DEFENCE

Americans' Perceptions of the International and Civil Defence Environments, 1968

The following is an extract of conclusions and implications of a report prepared by the Department of Sociology, University of Pittsburgh for the U.S. Office of Civil Defense.

The full report examines orientations of the American public on issues relevant to the international and civil defense environments in the Summer of 1968. The data were obtained from a national survey of approximately 1,500 respondents. Where possible, findings from past, similar surveys were compared with the 1968 date.

The survey revealed:

- *Perceived levels of international tension have been steadily rising and there is a higher likelihood of World War III.*
- *Attention has shifted from the USSR to China as the major threat to peace.*
- *Vietnam is seen as the greatest problem facing the U.S. and similar future involvements should be limited.*
- *An anti-ballistic missile system is generally approved, but little is known about it.*
- *A nuclear non-proliferation treaty and arms limitation are seen as desirable.*
- *There is evidence that "isolationism" is growing rather than polarization.*
- *National tension is high in race and law and order.*
- *The meaning of civil defense is ambiguous and local programs are viewed as inadequate.*
- *Civil defense knowledge levels are low.*
- *Respondents claim high interest in volunteer participation in normalcy and slow altruistic and sacrifice patterns in time of emergency.*
- *Negligible numbers have made home protection provisions.*
- *Relatively few have been exposed to domestic crises and fewer have taken protective measures.*
- *Americans show a strong inclination to be cooperative with government and support protective programs in time of emergency.*

Conclusions and Implications

The patterns that have emerged from the 1968 survey are not easily summed up succinctly. This is particularly true because of what appears to be a series of semi-contradictions, at least such appear from a surface look at the data.

Perhaps chief among the contradictions is one that is not entirely new to civil defense research. This consists of the clear pattern of support for civil defense versus the low levels of individual behavior. In the 1968 survey we did not use the customary measures of favorability since these were determined in 1966 to be sufficiently well tapped and well known. In short, nearly nine in ten respondents in 1966 were favorably disposed to civil defense. In 1968, instead, we used less self-evident measures that were intended to dig deeper into the conditions which support would still be manifested.

Our current data show, for example, that seven to nine of each ten respondents claim they would be altruistic in time of nuclear emergency. They would share their home (89 percent), would stock supplies (84 percent) or would mark the outside of their home with a shelter sign (67 percent). Whether, indeed, such high proportions would actually come through with what they say they would, the fact remains that in a "normal" period the American public has high cooperative and altruistic intentions. They claim that in difficult conditions they would make certain sacrifices which contribute to the common good. Even under conditions existing today, our respondents say that preparation for emergency is a very good thing and that emergency training programs are important (89 percent). Only one-fourth of respondents said they would refuse to participate. Typical of Americans, if not all people, the specific training programs which are more appealing are those that tend to impersonalize the individual and make him less intimately involved with others. Thus, more people would prefer to attend training drills (41 percent) than form a civil defense committee (27 percent) or recruit others (nine percent). These findings are suggestive rather than definitive. What they suggest is a high level of commitment and support for the goals of public protection as well as for certain means which the Office of Civil Defense has set forth as necessary.

This high commitment is, on the other hand, confounded by a relative absence of action by the American public. Commitment to OCD goals and means is basically unrelated to personal actions specifically recommended by OCD. For example, even though three-fifths of the sample had basements and six in ten of the basement owners said they are considering going or have decided to go to the basement in an emergency, only a negligible number have actually done anything about implementing a plan.

The high support but low action of the American pub-

lic must be seen further in an apparent context of fear and confusion prevailing today. The 1968 survey, of all our surveys, produced the highest proportions believing that world tensions were high (76 percent). Further, higher proportions than earlier believed in a higher likelihood of World War III. Couple these facts with our findings that in four potentially controversial areas of domestic life (race, poverty, age, and politics) the perceived tension levels were high (from 4.6 to 6.8 on a nine point tension scale). What results is a national mood of tension, confusion and fear.

Our rapidly changing and uncomfortable society seeks answers and guidance to both the domestic and international problems with which it is encumbered. Americans see the racial and crime problems, as well as Vietnam as the major problems facing the United States. These may be seen by the public as near-dilemmas which have no immediate solution and the average citizen feels powerless to contribute toward solution.

Still, with this confusing state of affairs, the American public appears to display a characteristic optimism as to the future. The present study, as well as past studies, have shown that the public has great confidence that its governments will find solutions to the problems confronting the United States and that such solutions will be to the ultimate benefit of the country. This optimistic confidence includes protection of people and resources in time of nuclear emergency as well as in foreign relations. The public's relatively high confidence in the government and its propensity to volunteer, joined with a sense of optimism for the future, and a propensity to be altruistic in time of emergency suggests that the public would demonstrate high levels of emergency cooperation if conditions so required.

This projection is made with the full realization that the public is ill informed insofar as civil defense information is concerned. Only two to three in ten respondents were able to give correct answers to questions which measured knowledge on sheltering and fallout. Further, the public has not been greatly exposed to emergency or disruptive crisis conditions such as illness, accidents or natural disasters. No more than three in ten had been involved in such crises, and very few of those who had been so involved took any protective measures to reduce the possibility of the crisis occurring again. Only three in ten respondents felt the local civil defense programs were adequate and we found that the very meaning of civil defense is ambiguous to most Americans. Only one in ten indicated that they would call civil defense in time of emergency.

These findings obviate the salience and visibility questions with which civil defense is genuinely interested. But other data suggest a character of the American public which conceivably compensates for the salience-visibility problem. In short, Americans will cooperate with agencies of protection when told what to do and how to do it and if an emergency situation exists.

This conclusion does not pertain to a period when "normalcy" exists. Past studies, underscored by the 1968 survey, indicate that the public does not act when a crisis is non-existent or non-probable. The public appears to be too cost-conscious to make significant investments in money, time or psychic energy unless there are immediately recognizable rewards. Thus, the public tends to think in terms of preventive behaviors for protection, especially if these entail costs, if the recommended behaviors are not tied into a national emergency.

At the same time, other data suggest still another characteristic of the public to which OCD should be sensitized. Americans tend to be joiners. They belong to a great variety of secondary associations, ostensibly finding satisfactions in various social relationships outside the family. The nature of civil defense is socially oriented, incorporating problems connected with shelter habitability. Our present data show considerable evidence that the public predicts relatively successful experiences in terms of shelter living. Social organization would be formed and leadership problems would be solved, though, realistically, shelter life would be uncomfortable. There is, thus, a display of optimism with regard to the capability of people getting along with each other and organizing for problem solution under conditions of high stress. Indeed, past studies have demonstrated that such outcomes do result. Americans are programmed for cooperative social arrangements and leadership, ostensibly due to their considerable experience in belonging to secondary groups. Further evidence is demonstrated in our findings that the American purports to be altruistic and would make his home available to others in time of emergency. It also should be noted that there is a growing series of movements for citizen participation and self-determination in the United States. This has direct implications for civil defense which is very considerably a "participation" phenomenon and one which must be responsive to local community norms.

The Office of Civil Defense needs to be conversant with and responsive to the character of the American and the social structural arrangements which he develops to solve everyday problems. Findings and interpretations from social science research can assist in providing meaning to seemingly contradictory information. The meaning has implications to the development or abandonment of official programs, as such appear to be required.▲

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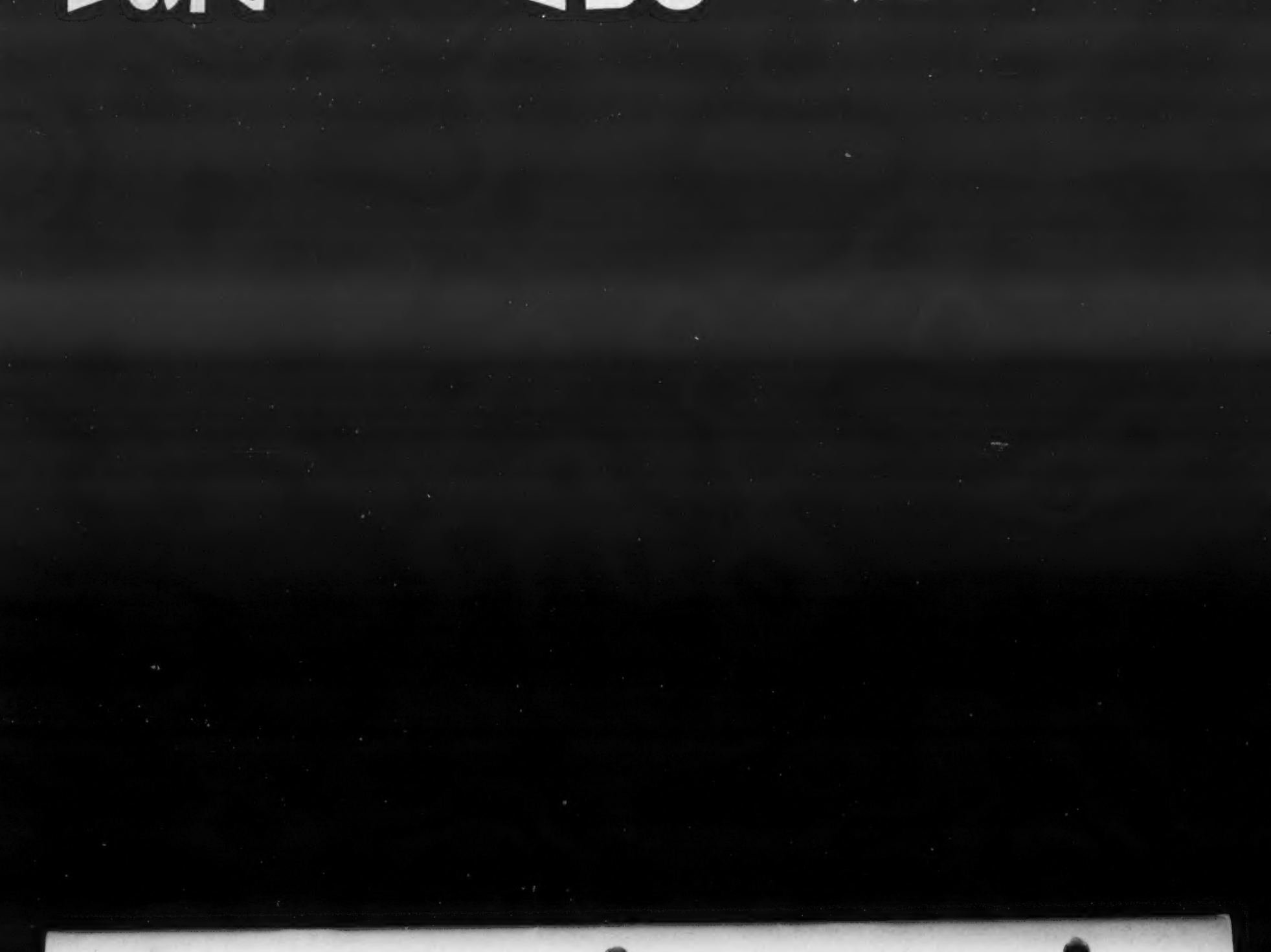
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